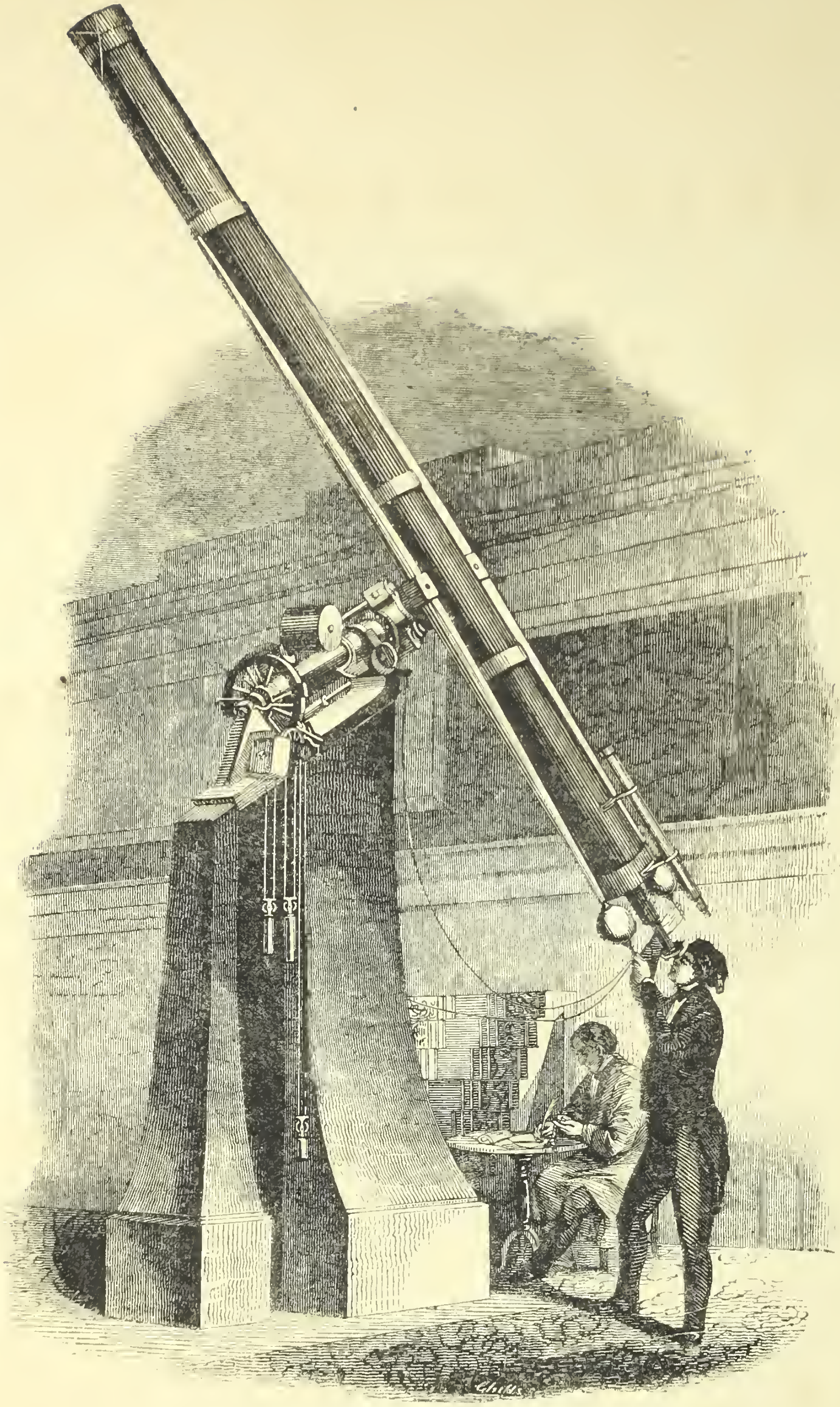
# SMITH'S ILLUSTRATED ASTRONOMY.

THE 2d TELESCOPE IN SIZE IN THE UNITED STATES, AT THE CINCINNATI OBSERVATORY

New-York:
DANIEL BURGESS & CO., 60 JOHN-STREET.
(LATE CADY & BURGESS.)



THE LARGEST TELESCOPES IN THE WORLD

| | |
|---|---|
| LORD ROSSE's Telescope, at Birr Castle, Ireland, | 56 feet in length. |
| SIR WM. HERSCHEL's do. at Greenwich, London, | 40 do. in length (not in use ) |
| The Dorpat Telescope, at Dorpat (Russia,) PROF. STRUVE, | 16 " |
| SIR JAMES SOUTH's Telescope at London, | 19 " |
| Cincinnati Telescope, (Ohio,) PROF. MITCHEL, | 17 " |
| Telescope at Cambridge, Mass | 23 " |

## HINTS TO TEACHERS.

The author would recommend that whenever a lesson is given to a class, that the teacher call their particular attention to the illustration, and explain, if necessary, the diagrams relating to the lesson given, at the same time questioning the whole class upon the subject; and inviting any pupil who does not fully understand the subject to ask any questions relating to it he may think proper. This will prepare the pupil, when he is studying his lesson, to have a right conception of what he is learning. It is not expected by the author that the teacher will confine himself solely to the questions given in the book; but that he will ask many which may occur to him at that time, and which may lead the pupil off from the routine of the book, and induce him to apply the principles which he is endeavoring to acquire.

He would also particularly recommend, that the teacher when hearing a recitation, change the question or put it in a different form, in all cases where it will admit of it. For example:

What is the attraction, by which all particles of matter tend toward each other, called? The attraction of gravitation.

What is the attraction of gravitation? It is that attraction by which all particles of matter tend toward each other.

What is the point in the heavens directly over our heads called? The zenith.

What is the zenith? It is that point in the heavens directly over our heads.

(REVISED AND ENLARGED.)

SMITH'S

# ILLUSTRATED ASTRONOMY,

DESIGNED FOR THE USE OF THE

**PUBLIC OR COMMON SCHOOLS**

IN THE UNITED STATES.

ILLUSTRATED WITH

**NUMEROUS ORIGINAL DIAGRAMS.**

BY ASA SMITH,
Principal of Public School No. 12, City of New York.

NINETEENTH EDITION.

New-York:
DANIEL BURGESS & CO., 60 JOHN-STREET.

1856.

# CONTENTS.



# ILLUSTRATIONS.



# SIDEREAL MAPS.





Stereotyped by
Vincent L. Dill,
128 Fulton Street, N. Y.

C. A. Alvord, Printer

# PREFACE



## TO THE REVISED EDITION.

Nearly six years have elapsed since the publication of this *Illustrated Astronomy*; during this time many *new planets* or Asteroids have been discovered; a notice of which will be found in its proper place; also a notice of Professor Bond's new theory in regard to Saturn's rings.

The favor with which this work has been received by teachers and the public generally has far exceeded the author's expectations, it having run through fifteen Editions since its publication. It has been thoroughly revised, and the *new* discoveries are brought up to the present date; five new illustrations have been added and a new set of *Electrotype plates* have been procured at a great expense, which give a very distinct and beautiful diagram.

It has been the object of the author of this *Illustrated Astronomy*, to present all the distinguishing principles in physical Astronomy with as few words as possible; but with such occular demonstrations, by way of diagrams and maps, as shall make the subject easily understood. The letter press descriptions and the illustrations will invariably be found at the same opening of the book; and more explanatory cuts are given, and at a much less price than have been given in any other elementary Astronomy.

This work is designed for common schools, but may be used with advantage as an introductory work in high-schools and academies. In the preparation of these pages most of the best works in our language have been consulted, and the best standard authorities, with regard to new discoveries and facts, have governed the author's decisions.

The Diagrams, which are larger and more full than those of any other work adapted to common schools, are most of them original in their design, and exhibit the positions and phases of the planets in their orbits. The drawings being upon the principal of perspective, exhibit the inclinations of their several axes to the planes of their orbits more correctly than has hitherto been done in any other popular work. It is well to intimate to the young elementary student, who has made himself some what acquainted with the sublime mechanism of the solar system, that there is something more magnificent beyond. Accordingly the author has given a few Sidereal Maps, just to awaken in the young astronomer the amazing conception, that unnumbered suns and revolving worlds occupy the depths of space far beyond the confines of our planetary system. By these maps he will be able to learn the relative positions of the principal constellations and stars, which will be found useful and interesting to him in subsequent investigations of the ennobling truths of mathematical Astronomy.

The author is not so vain as to suppose that he has been able to present to teachers a faultless work; but in his own practice, finding it tedious and often difficult to explain all the representable phenomena of the science on the *black-board*, and finding also a general concurrence of opinion among teachers most interested in the study of Astronomy, that a cheap, compact, and illustrated work is necessary in our common schools, he has attempted the production of such a work. The success of the work and the favor with which it has been received, sufficiently prove its superiority over all other works for the instruction of pupils in the general outlines of the science of Astronomy, and satisfies the author that he has not labored in vain in the production of this work.

Objections which are sometimes urged against questions and answers, in an elementary work, will not, the Anthor hopes, be urged in this case, as the pupil has the subject, fully illustrated, continually before the eye, while he is learning his lesson.

To the Teachers, of our common country, this work is most respectfully dedicated, in the sincere desire that the cause of education may be benefitted, and the labors of instruction in Astronomy may be rendered more easy and pleasant, from the illustrations it contains.

ASA SMITH, Principal of Ward School No. 11, (*Late Public School, No.* 12,)
Seventeenth Street, near Eighth Avenue, City of New York.

## NAMES AND CHARACTERS OF THE SIGNS, PLANETS, AND ASPECTS.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Aries, | ♈ | Sagittarius | ♐ | Earth, | ⊕ | Hebe,* | | Quartile, | □ |
| Taurus, | ♉ | Capricornus, | ♑ | Mars, | ♂ | Iris,* | | Trine, | △ |
| Gemini, | ♊ | Aquarius, | ♒ | Vesta, | ⚶ | Jupiter, | ♃ | Opposition, | ☍ |
| Cancer, | ♋ | Pisces, | ♓ | Juno, | ⚵ | Saturn, | ♄ | Ascending Node, | ☊ |
| Leo, | ♌ | Sun, | ☉ or ⊙ | Ceres, | ⚳ | Herschel, | ♅ | Descending Node, | ☋ |
| Virgo, | ♍ | Moon, | ● ○ ◐ ◑ | Pallas, | ⚴ | Leverrier, | ♆ | ................ | |
| Libra, | ♎ | Mercury, | ☿ | Astræa,* | | Conjunction, | ☌ | ................ | |
| Scorpio, | ♏ | Venus, | ♀ | Flora,* | | Sextile, | * | ................ | |

* Not determined.

**The following is a list of the names of the new Asteroids, date of discovery, and by whom discovered.**

| Name and Number. | Date of Discovery | Name of Discoverer. | Name and Number. | Date of Discovery | Name of Discoverer. |
|---|---|---|---|---|---|
| 1. Ceres.......... | 1800, Jan. 1. | Piazza, of Sicily. | 13. Egeria........... | 1850, Nov. 2. | De Gasparis. |
| 2. Pallas.......... | 1802, Mar. 28. | Olbers, of Bremen. | 14. Irene............ | 1851, May 19. | Hind. |
| 3. Juno........... | 1804, Sept. 1. | Harding. | 15. Eunomia......... | 1851, July 29. | De Gasparis. |
| 4. Vesta.......... | 1807, Mar. 29. | Olbers. | 16. Psyche.......... | 1852, Mar. 17. | De Gasparis. |
| 5. Astræa......... | 1845, Dec. 8. | Hencke, of Germany. | 17. Thetis........... | 1852, April 17. | Luther, of Germany. |
| 6. Hebe.......... | 1847, July 1. | Hencke. | 18. Melpomene....... | 1852, June 24. | Hind. |
| 7. Iris........... | 1847, Aug. 13. | Hind, of London. | 19. Fortuna.......... | 1852, Aug. 22. | Hind. |
| 8. Flora.......... | 1847, Oct. 18. | Hind. | 20. Massilia......... | 1852, Sept. 22. | De Gasparis. |
| 9. Metis.......... | 1848, April 26. | Graham, of Ireland. | 21. Lutetia.......... | 1852, Nov. 15. | Goldschmidt, of Germany. |
| 10. Hygeia......... | 1849, April 12. | De Gasparis, of Naples. | 22. Calliope.......... | 1852, Nov. 16. | Hind. |
| 11. Parthenope...... | 1850, May 11. | De Gasparis. | 23. Thalia........... | 1852, Dec. 15. | Hind. |
| 12. Victoria........ | 1850, Sept. 13. | Hind. | | | |


LEVERRIER
JUNO
VESTA
PALLAS
CERES
MARS
EARTH
JUPITER
VENUS
ASTRÆA
MERCURY
COMET
SATURN
HERSCHEL
JAN
FEB
JUNE
JULY
AUG
SEP
OCT
NOV

# INTRODUCTION TO ASTRONOMY.

## LESSON I.

*Question.* WHAT is the body called upon which we live?

*Answer.* It is called the EARTH, or WORLD.

*Q.* What idea had the ANCIENTS respecting the shape of the earth?

*A.* They believed it was an extensive plain, rendered uneven by hills and mountains.

*Q.* Why did they think it was an extended plain?

*A.* Because they formed their opinions from appearances only.

*Q.* Did they believe that the earth had any motion?

*A.* They did not; they believed that the earth rested on a solid, immovable foundation.

[They very naturally came to this conclusion, as they were entirely ignorant of the laws of attraction or gravitation. They believed that if the earth were to turn over, that every thing would be precipitated from its surface.]

*Q.* Had they any definite ideas respecting what held the earth up?

*A.* Their views were very vague and unsatisfactory.

[There have been many absurd ideas advanced, at different ages of the world, as to what supported the earth. Some supposed it to be shaped like a CANOE, and to float upon the waters; others, that it rested upon the back of an ELEPHANT, or huge TURTLE; while, according to mythology, Atlas supported it upon his shoulders: but, what kept the waters in their place, or upon what the Elephant, Turtle, or Atlas stood—this was a mystery they COULD NEVER SOLVE.]

*Q.* Did they believe the earth extended the same distance in all directions?

*A.* They believed it to extend much farther from east to west than from north to south.

[They observed that in going east or west, on the same parallel of latitude, no change took place in the appearance of the heavens; but in going north or south, on the same meridian, every sixty miles caused a difference of one degree in the elevation of the pole, and in the position of the circles of daily motion of the sun and other heavenly bodies; therefore they concluded that the earth was very long from east to west, but comparatively narrow from north to south. From this originated the use of the TERMS longitude and latitude; longitude meaning length, and latitude, breadth.]

*Q.* What ideas had they respecting the motions of the sun, moon, and Stars?

*A.* They supposed that they revolved around the earth, from east to west, every day.

*Q.* What was this system called, that supposed the earth to be at rest in the centre, and all the heavenly bodies to revolve around it?

*A.* The Ptolemaic system.

[Ptolemy asserted, that the sun, moon, planets, and stars revolved around the earth, from east to west, every 24 hours; and to account for their not falling upon the earth, when they passed over it, he supposed that they were each fixed in a separate hollow crystalline globe, one within the other. Thus the moon was in the first; Mercury in the second; Venus in the third; the sun in the fourth; Mars in the fifth; Jupiter in the sixth; Saturn in the seventh;—(the planet Herschel was not known at this time)—the fixed stars in the eighth. He supposed the stars to be in one sphere as they are kept in the same positions with respect to each other. To permit the light of the stars to pass down to the earth, he supposed these spheres or globes were perfectly clear or transparent like glass. The power which moved these spheres, he supposed, was communicated from above the sphere which contained the stars.]

## LESSON II.

*Question.* EVERY one is conscious that the sun, which rises daily in the east and sets in the west, is the same body; where does it go during the night?

*Answer.* It appears to pass round under the earth.

*Q.* When we look out upon the stars, on successive evenings, they appear to have a definite position with respect to each other, and a westward movement like the sun; what motion do they appear to have from their setting to their rising?

*A.* They appear to pass under the earth.

*Q.* From the north to the south point of the heavens, there is a continuous arc of stars, and in their passage under the earth they are not at all disarranged, what can you infer from this fact?

*A.* That they pass completely around the earth, and every thing attached to it.

*Q.* We see no body at rest that does not touch some permanent support, but we see bodies in motion supported for different lengths of time without resting upon any other surface; if the earth is hung upon nothing, is it probably at rest?

*A.* It is more probable that it is in motion.

*Q.* If we throw a ball, does the same side always remain forward?

*A.* It does not; it turns over continuously.

*Q.* What do we call the line round which it turns?

*A.* Its axis.

*Q.* If a fly were on the ball, would distant objects appear to him to be stationary?

*A.* They would appear to revolve around the ball, as often as it turned over.

*Q.* If the earth is moving in space, is it in accordance with the known motion of ordinary bodies, to suppose that the same side remains forward?

*A.* It is not. It is more reasonable to suppose that it turns on its axis.

*Q.* If the earth turns, and we are carried round on its surface, what appearance must the sun and distant stars necessarily present?

*A.* They must appear to move around the earth in the opposite direction.

## LESSON III.

*Question.* WHAT other reason can you give for the earth's turning?

*Answer.* The stars are so distant, that their motion would be immensely swift, in comparison with the motion of the earth, to produce the same effect.

*Q.* But have we not positive proof, and that too of different kinds, that the earth turns on its axis?

*A.* We have.—1. The shape of the earth, elevated at the equator and depressed at the poles, can be accounted for on no other supposition.

2. A body at the equator, dropped from a great height, falls eastward of the perpendicular.

3. The trade winds and ocean currents in the tropical regions are clearly traceable to the same cause.

*Q.* If the earth is moving in space, does it proceed in a straight line?

*A.* It does not; but it would do so, were it not attracted by other bodies.

*Q.* What is the attraction, by which all particles of matter tend towards each other, called?

*A.* The attraction of gravitation.

*Q.* What large body, by its attraction, causes the earth to revolve around it in a curve line?

*A.* The sun.

*Q.* What other similar bodies revolve around the sun?

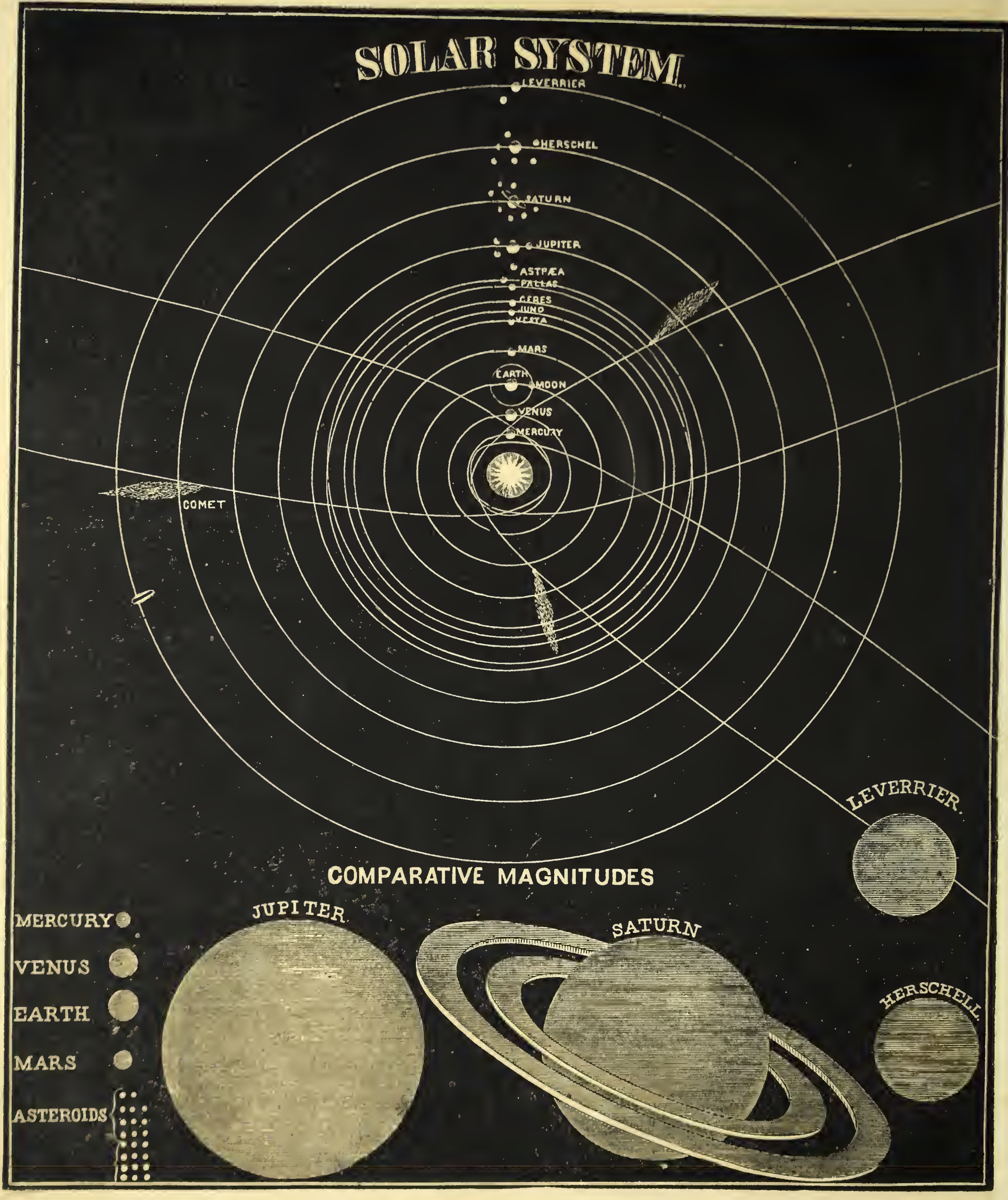
*A.* The planets.

*Q.* What may we call the earth, when considered with regard to its size, shape, motions, &c.?

*A.* One of the planets.

*Q.* What science describes these characteristics of the earth, and other heavenly bodies?

*A.* Astronomy.


SOLAR SYSTEM.
LEVERRIER
HERSCHEL
SATURN
JUPITER
ASTRÆA
PALLAS
CERES
JUNO
VESTA
MARS
EARTH
MOON
VENUS
MERCURY
COMET
COMPARATIVE MAGNITUDES
MERCURY
VENUS
EARTH
MARS
ASTEROIDS
JUPITER.
SATURN
LEVERRIER.
HERSCHELL.

## LESSON IV.

### ASTRONOMY.

*Question.* WHAT is astronomy?

*Answer.* Astronomy is the science which treats of the heavenly bodies.

*Q.* What are the heavenly bodies?

*A.* The sun, moon, planets, comets, and stars,

*Q.* What are some of their characteristics, of which astronomy treats?

*A.* Their appearance, size, shape, arrangement, distance, motions, physical constitution, mutual influence on each other, &c.

*Q.* Are they all of the same magnitude, or size?

*A.* The sun and stars are much larger than the other bodies.

*Q.* Are they all at the same distance from the earth?

*A.* They are not; the moon is the nearest, and the stars the most distant.

*Q.* Do they all emit light of themselves?

*A.* They do not.

*Q.* How are they divided in this respect?

*A.* They are divided into two classes, luminous and opake.

*Q.* What is a luminous body?

*A.* It is a body which shines by its own light.

*Q.* What is an opake body?

*A.* It is a body which shines only by reflecting the light of a luminous body.

*Q.* Which are the luminous bodies in the heavens?

*A.* The sun and fixed stars are luminous bodies.

*Q.* Which are the opake bodies in the heavens?

*A.* The moon, planets, and comets.

*Q.* Why do the moon, planets, and comets appear luminous?

*A.* Because they reflect to us the light of the sun.

*Q.* What is the shape of the heavenly bodies?

*A.* They are round like a globe or ball.

*Q.* What do the sun, moon, planets, and comets constitute?

*A.* They constitute the solar system.

## LESSON V.

### THE SOLAR SYSTEM.

*Question.* How are the bodies constituting the solar system arranged?

*Answer.* The sun is placed in the centre of the system, with the planets and comets revolving around it at unequal distances.

*Q.* How many planets are there in the solar system?

*A.* Fifty-two is the number known at present.

*Q.* How are they divided with respect to their motion?

*A.* They are divided into two classes, primary and secondary.

*Q.* What is a primary planet?

*A.* It is a planet which revolves around the sun only.

*Q.* What is a secondary planet?

*A.* It is a planet which revolves around its primary, and with it around the sun.

*Q.* What are the secondary planets usually called?

*A.* They are called satellites or moons.

*Q.* How many primary planets are there?

*A.* 8 large planets and 23 asteroids or small planets.

*Q.* What are their names, beginning at the sun?

*A.* Mercury, Venus, the Earth, Mars, (Twenty-three Asteroids or small Planets,) Jupiter, Saturn, Herschel, or Uranus, and Leverrier, or Neptune.

*Q.* How many secondary planets or moons are there?

*A.* Twenty-one.

*Q.* Which planets have moons?

*A.* The Earth has 1, Jupiter 4, Saturn 8, Herschel 6, and Leverrier 2.

## LESSON VI.

*Question.* How many revolutions has a primary planet?

*Answer.* Two; one on its axis, and another around the sun.

*Q.* What is the axis of a planet?

*A.* It is a straight line, round which it turns.

*Q.* What is the path called, in which a planet revolves around the sun?

*A.* It is called its orbit.

*Q.* What is the earth's orbit called?

*A.* It is called the ecliptic.

*Q.* Why is it so called?

*A.* Because eclipses take place, only when the moon is in its plane.

*Q.* How many revolutions has a secondary planet?

*A.* Three. 1st, the revolution upon its axis; 2d, the revolution around its primary; 3d, the revolution with its primary around the sun.

*Q.* How are the planets divided, with respect to their distance from the sun?

*A.* Into inferior and superior, according as their distance from the sun is inferior or superior to that of the earth.

*Q.* Which are the inferior planets?

*A.* Mercury and Venus.

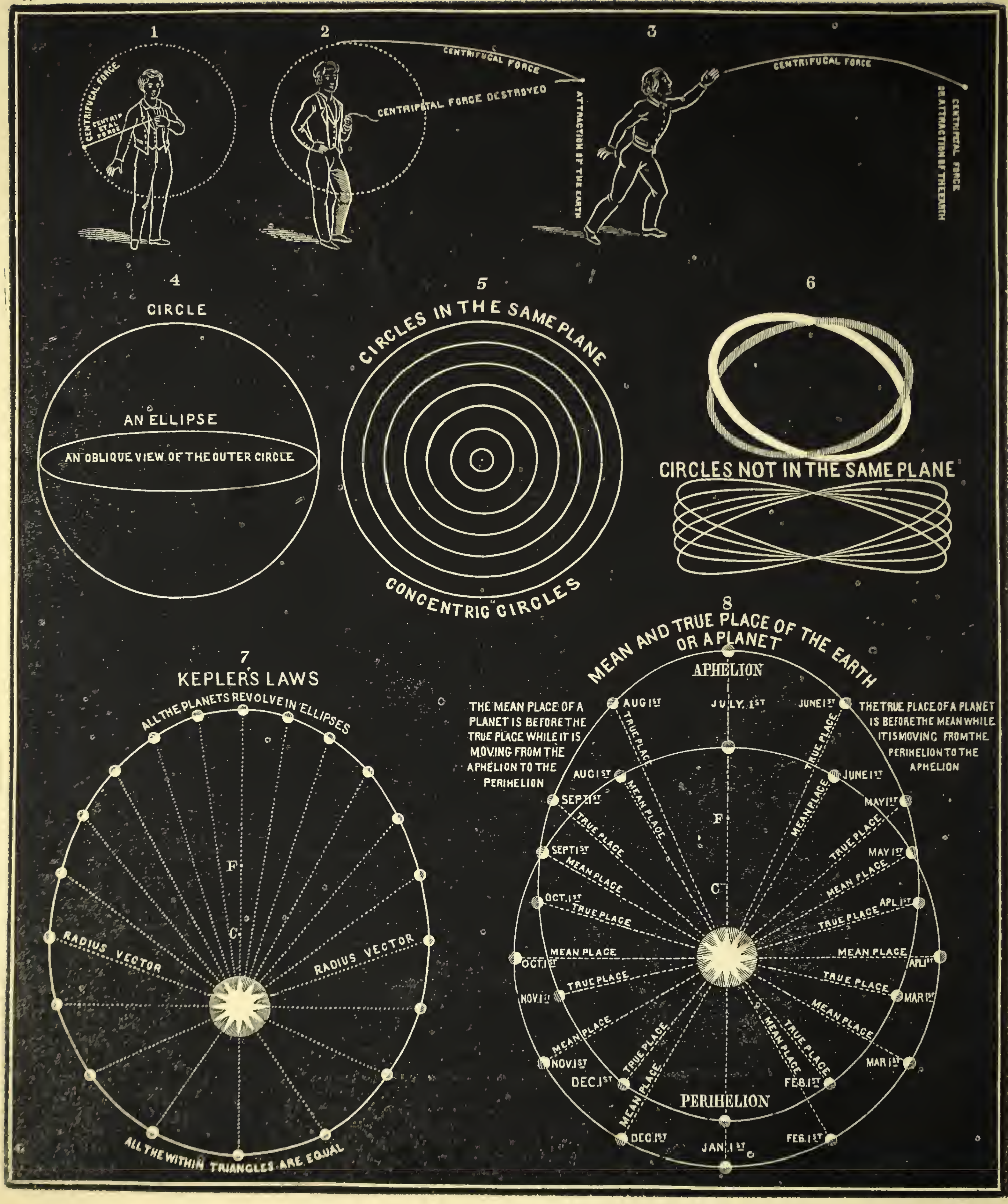
*Q.* Which are the superior?

*A.* Mars, the Asteroids, Jupiter, Saturn, Herschel, and Leverrier.

## LESSON VII.

| DIAMETERS. | | MAGNITUDES; THE EARTH BEING 1. | DISTANCES FROM THE SUN. | REVOLUTION ON THEIR AXIS. | | REVOLUTION AROUND THE SUN. | |
|---|---|---|---|---|---|---|---|
| | Miles. | | Miles. | Days. | Hours. | Years. | Days. |
| Sun, | 886,952 | 1,384,472 | | 25 | 10 | | |
| Mercury, | 3,200 | ...... $\frac{1}{17}$ | 37,000,000 | | 24 | | 88 |
| Venus, | 7,700 | ...... $\frac{9}{10}$ | 68,000,000 | | $23\frac{1}{2}$ | | 224 |
| Earth, | 7,912 | ...... 1 | 95,000,000 | | 24 | 1 | 0 |
| Mars, | 4,189 | ....... $\frac{1}{7}$ | 142,000,000 | | $24\frac{1}{2}$ | 1 | 321 |
| Vesta, | 270 | ... $\frac{1}{28000}$ | 225,000,000 | Unknown. | | 3 | 230 |
| Astræa, | unknown. | Unknown. | 253,000,000 | " | | 4 | 105 |
| Juno, | 1,400 | ..... $\frac{1}{180}$ | 254,000,000 | " | | 4 | 131 |
| Ceres, | 1,600 | ..... $\frac{1}{135}$ | 263,000,000 | " | | 4 | 222 |
| Pallas,* | 2,100 | ...... $\frac{1}{35}$ | 263,000,000 | " | | | |
| Hebe, | unknown. | Unknown. | Unknown. | " | | | |
| Iris, | " | " | " | " | | | |
| Flora, | " | " | " | " | | | |
| Jupiter, | 87,000 | 1,280 | 485,000,000 | | 10 | 11 | 314 |
| Saturn, | 79,000 | 1,000 | 890,000,000 | | $10\frac{1}{2}$ | 29 | 167 |
| Herschel, | 35,000 | 80 | 1,800,000,000 | | | 84 | 5 |
| Leverrier, | 35,000 | 80 | 2,850,000,000 | | | 166 | |

* Herschel estimated the diameter of each of the asteroids to be under 200 miles. Their great distance, extreme smallness, and nebulous appearance, render it extremely difficult to ascertain their size with accuracy.


1
CENTRIFUGAL FORCE
CENTRIPETAL FORCE
2
CENTRIFUGAL FORCE
CENTRIPETAL FORCE DESTROYED
ATTRACTION OF THE EARTH
3
CENTRIFUGAL FORCE
CENTRIPETAL FORCE OR ATTRACTION OF THE EARTH
4
CIRCLE
AN ELLIPSE
AN OBLIQUE VIEW OF THE OUTER CIRCLE
5
CIRCLES IN THE SAME PLANE
CONCENTRIC CIRCLES
6
CIRCLES NOT IN THE SAME PLANE
7
KEPLER'S LAWS
ALL THE PLANETS REVOLVE IN ELLIPSES
F
C
RADIUS VECTOR
RADIUS VECTOR
ALL THE WITHIN TRIANGLES ARE EQUAL
8
MEAN AND TRUE PLACE OF THE EARTH OR A PLANET
APHELION
THE MEAN PLACE OF A PLANET IS BEFORE THE TRUE PLACE WHILE IT IS MOVING FROM THE APHELION TO THE PERIHELION
THE TRUE PLACE OF A PLANET IS BEFORE THE MEAN WHILE IT IS MOVING FROM THE PERIHELION TO THE APHELION
AUG 1ST
JULY 1ST
JUNE 1ST
TRUE PLACE
TRUE PLACE
AUG 1ST
MEAN PLACE
MEAN PLACE
JUNE 1ST
SEPT 1ST
MAY 1ST
TRUE PLACE
TRUE PLACE
F
SEPT 1ST
MEAN PLACE
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APL 1ST
MEAN PLACE
MEAN PLACE
OCT. 1ST
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TRUE PLACE
TRUE PLACE
NOV. 1ST
MAR 1ST
MEAN PLACE
MEAN PLACE
MEAN PLACE
TRUE PLACE
TRUE PLACE
NOV. 1ST
MAR 1ST
DEC. 1ST
FEB. 1ST
MEAN PLACE
PERIHELION
DEC 1ST
JAN 1ST
FEB. 1ST

## LESSON VIII.

### CENTRIPETAL AND CENTRIFUGAL FORCE.

*Question.* WHAT is that force called with which all bodies attract each other in proportion to their mass?

*Answer.* The attraction of gravitation.

*Q.* What is centripetal force?

*A.* It is the force which draws a body towards the centre round which it is revolving.

*Q.* What large body by its attraction exerts a centripetal force upon all the primary planets and comets?

*A.* The sun.

*Q.* What body exerts a centripetal force upon the moon?

*A.* The earth.

*Q.* What bodies exert a centripetal force upon the other moons?

*A.* The primary planets around which they revolve.

*Q.* What is the centrifugal force of a heavenly body?

*A.* It is that force which moves it forward in its orbit.

*Q.* How do these two forces cause the planets to move?

*A.* They cause them to move in circular or elliptical orbits.

*Q.* What is a circle?

*A.* It is a plane figure bounded by a curve line, all parts of which are equally distant from the centre.—(FIG. 4.)

*Q.* What is an ellipse?

*A.* It is an oblique view of a circle. (FIG. 4.)

[NOTE.—Teachers should be sure that the pupils understand the definition of an ellipse, because in viewing some of the diagrams they may receive a wrong impression. In the diagram representing the seasons, the earth's orbit appears very elliptical: this would be well understood by the pupil, should the teacher call his particular attention to it. Also, a plane of a circle should be well understood.]

*Q.* What are the foci of an ellipse?

*A.* They are the two points around which the ellipse is drawn. (FIG. 7.)

Q. Where are these points situated?

*A.* In the greater axis, at equal distances from the centre.

*Q.* What is the eccentricity of an ellipse?

*A.* It is the distance from the centre to either of the foci. (FIG. 7.)

*Q.* Where is the sun situated within the orbit of each planet?

*A.* It is situated in one of the foci. (FIG. 8.)

*Q.* When are circles in the same plane? (FIG. 5.)

*A.* When their planes lie in the same straight line.

*Q.* When are circles not in the same or parallel planes?

*A.* When their planes intersect each other. (FIG. 6.)

## LESSON IX.

*Question.* How many laws did Kepler discover, which bear his name?

*Answer.* Three.

*Q.* To what do they relate?

*A.* They relate to the motions of the planets.

*Q.* What is the first law of Kepler?

*A.* That all the planets revolve in elliptical orbits, having the sun in one of their foci. (FIG. 7.)

*Q.* What is the second law?

*A.* That the radius vector passes over equal spaces in equal portions of time.

*Q.* What is the radius vector?

*A.* It is a line drawn from the sun to a planet, in any part of its orbit. (FIG. 7.)

*Q.* What is the third law?

*A.* It is that the squares of the times of the revolutions of the planets around the sun, are proportional to the cubes of their mean distances from the sun.

### THE MEAN AND TRUE PLACE OF A PLANET.

*Q.* What is the mean place of the earth, or a planet in its orbit?

*A.* It is that point in its orbit where it would be if it moved in a circle, and with the same velocity at all times. (FIG. 8.)

*Q.* What is the true place of the earth or a planet?

*A.* It is that point in its orbit where it really is at any given time. (FIG. 8.)

*Q.* What is the aphelion?

*A.* It is that point in the orbit of the earth or planet farthest from the sun. (FIG. 8.)

*Q.* When is the earth in the aphelion, or farthest from the sun?

*A.* July 1st. (FIG. 8.)

*Q.* What is the perihelion?

*A.* It is that point in the orbit of the earth or planet nearest to the sun. (FIG. 8.)

*Q.* When is the earth in the perihelion, or nearest to the sun?

*A.* January 1st. (FIG. 8.)

## LESSON X.

*Question.* IN what points of a planet's orbit do its mean and true places coincide?

*Answer.* At the aphelion and perihelion. (SEE FIG. 8.)

*Q.* What straight line connects these points, and passes through the sun?

*A.* The apsis line.

*Q.* When is the true place of the earth or planet behind its mean place?

*A.* While it is moving from the aphelion to the perihelion. (SEE FIG. 8.)

*Q.* When is the true place of the earth or planet before its mean place?

*A.* While it is moving from the perihelion to the aphelion? (SEE FIG. 8.)

*Q.* When does it move with the least velocity?

*A.* When it is at its greatest distance from the sun.

*Q.* When is the motion of the earth or planet in its orbit increasing?

*A.* When it is moving from the aphelion to the perihelion.

*Q.* Why does the motion increase from the aphelion to the perihelion?

*A.* Because it is approaching nearer to the sun.

*Q.* What causes it to approach the sun?

*A.* The centrifugal force at the aphelion is not sufficiently great to prevent its falling towards the sun.

*Q.* When does the earth or planet move with the greatest velocity?

*A.* When it is the nearest to the sun.

*Q.* When is the motion of the earth or planet decreasing?

*A.* While it is moving from the perihelion to the aphelion.

*Q.* Why does the motion decrease from the perihelion to the aphelion?

*A.* Because the planet is receding from the sun.

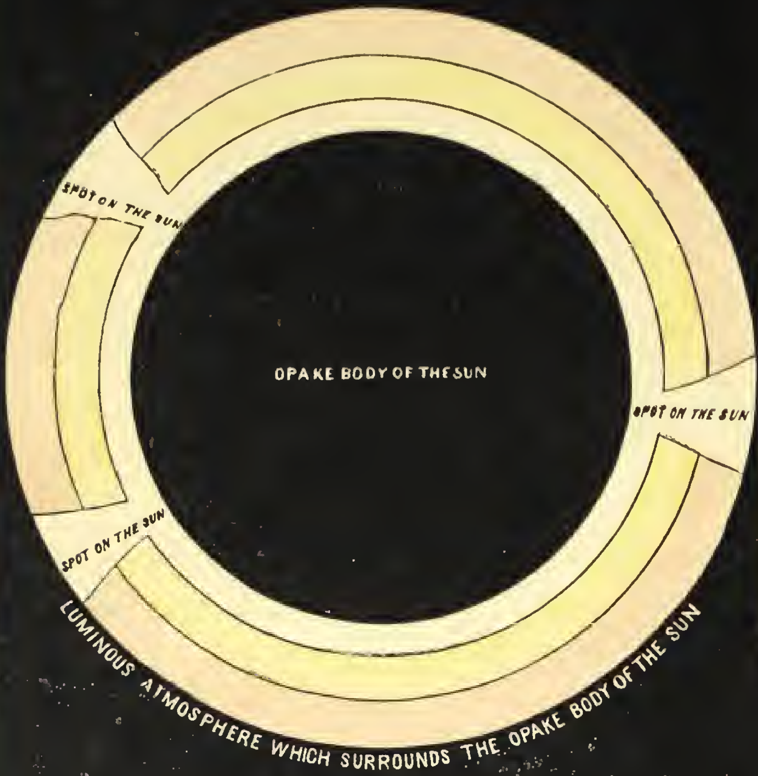
*Q.* What causes it to recede from the sun?

*A.* The centrifugal force at the perihelion is so great as to carry it farther from the sun.

#### CENTRIPETAL AND CENTRIFUGAL FORCES.

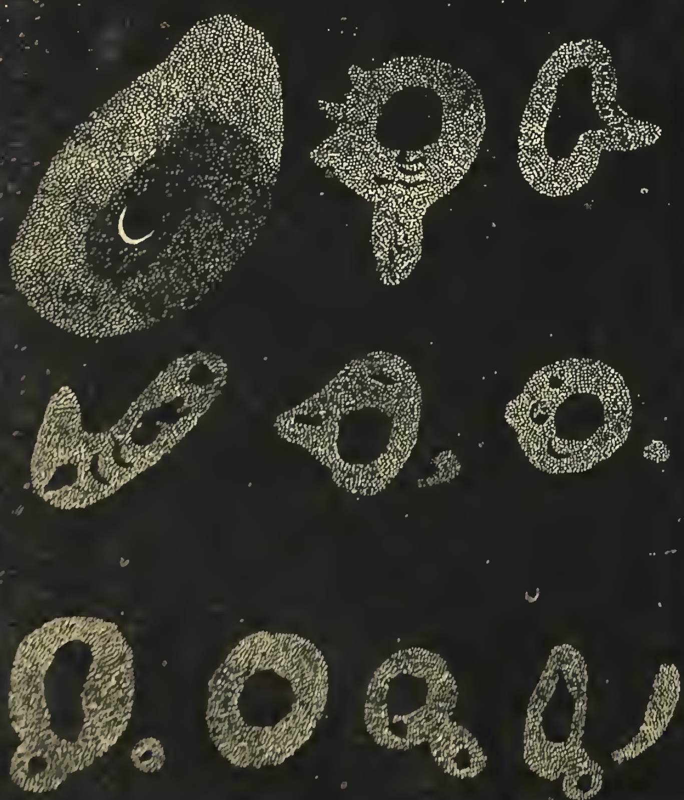
A body projected by any force would always move forward in a straight line, and with the same velocity, unless acted upon by some other force. A hall discharged from a gun or thrown from the hand soon looses its projectile force by the resistance of the atmosphere, and is brought to the ground by the attraction of the earth, or centripetal force. (FIG. 3) These two forces can be well illustrated, (SEE FIG. 1, 2,) by tying a string to a ball and swinging it round; the centrifugal force imparted to the ball by the hand and by means of the string, causes the ball to move in a circle; but if the string should break, the centrifugal force would carry it off in a straight line, if the ball were not attracted by the earth. The string corresponds to the attraction of the sun in our solar system, which causes the planets to move in regular curves around the sun, instead of straight line. If the attraction of the sun or centripetal force should cease, the planets would fly off into space in straight lines; but if the centrifugal force should cease and the centripetal force continue, the planets would immediately fail into the sun.

A CUT SECTION OF THE SUN
SHOWING THE SPOTS, THE LUMINOUS ATMOSPHERE, AND THE OPAKE BODY OF THE SUN.

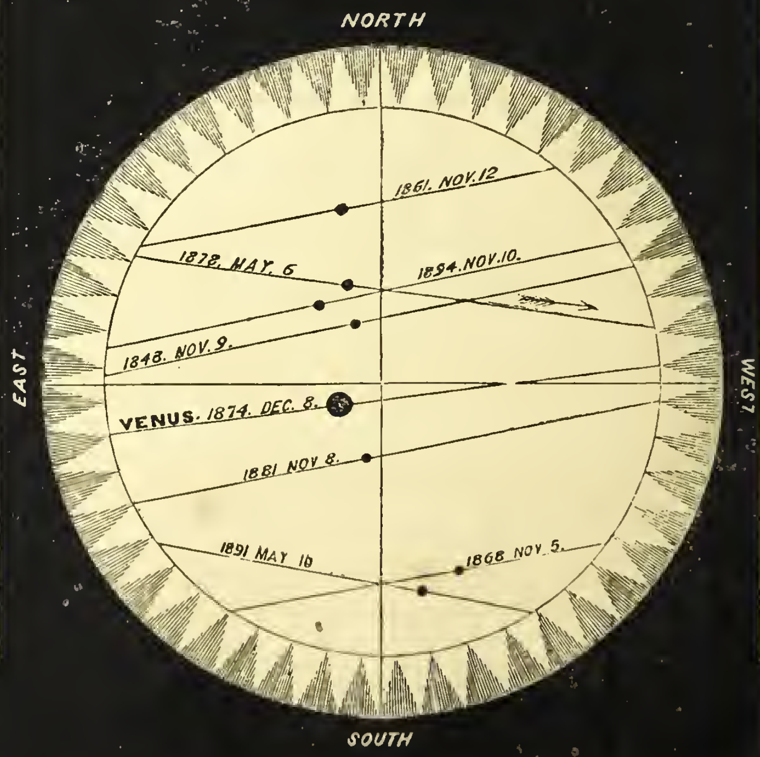



SPOTS ON THE SUN.


REMARKABLE SPOTS THAT HAVE BEEN DISCOVERED UPON THE SUN



TRANSITS OF MERCURY & VENUS UNTIL THE YEAR 1900



## LESSON XI.

### THE SUN.

*Question.* WHAT body is in the centre of the solar system?

*Answer.* The sun.

*Q.* Describe the sun?

*A.* The sun is a large luminous body, which gives light and heat to the whole solar system.

*Q.* What is the diameter of the sun?

*A.* 886,952 miles.

*Q.* How much larger is the sun than the earth?

*A.* It is 1,384,472 times greater.

*Q.* What is the specific gravity of the sun?

*A.* It is $1\frac{1}{3}$ the weight of water. (1.38.)

*Q.* What is the size of the sun compared with the planets?

*A.* It is 500 times as great as the bulk of all the planets.

*Q.* What can you say of its mass or weight?

*A.* It is about 750 times the mass of all the planets.

*Q.* What is the distance of the sun from the earth?

*A.* It is about 95,000,000 of miles.

*Q.* What did the ancient astronomers consider the sun to be?

*A.* A large globe of fire.

*Q.* What do astronomers at the present day consider it to be?

*A.* An opake body like the earth, surrounded by a luminous atmosphere.

*Q.* What motions has the sun?

*A.* It has three motions—1st, on its axis; 2d, around the centre of gravity of the solar system; 3d, around the centre of the universe.

[The term universe is used by astronomers, though perhaps improperly, to designate the great cluster or firmament of stars in which our sun is situated.—(SEE PAGES 45 and 46) This cluster includes all the single stars that can be seen with the naked eye, and all those composing the galaxy or milky way The number of stars or suns in the cluster is estimated at many millions; all which, like our sun, are supposed to revolve around the common centre of gravity of the whole cluster. Several thousand other distinct clusters or nebulæ, situated without our firmament, can be seen by the best telescopes, nearly all of which are invisible to the unassisted eye.]

## LESSON XII.

*Question.* WHAT is the inclination of the sun's axis to that of the ecliptic?

*Answer.* About $7\frac{1}{3}$ degrees.

*Q.* In what time does it revolve on its axis?

*A.* In about 25 days and a half.

*Q.* How is the revolution of the sun on its axis determined?

*A.* By spots on its surface, which first appear on the east side, pass over, and disappear on the west side.

*Q.* What is the nature of these spots?

*A.* They are supposed to be openings in the luminous atmosphere, which enable us to see the dark body of the sun.

*Q.* What occasions these openings in the luminous atmosphere?

*A.* They have been attributed to storms and various other causes.

*Q.* Do these spots undergo any changes?

*A.* They are constantly changing, and sometimes very rapidly. Some have appeared, others disappeared suddenly.

*Q.* On what part of the sun do they appear?

*A.* Within about thirty degrees of the equator.

*Q.* Is the surface of the sun, in the region of the spots, tranquil or agitated?

*A.* It is in a state of continual and violent agitation.

*Q.* What reasons have we to suppose that the luminous part of the sun is intensely hot?

*A.* 1st, the heat of its rays, when collected into a focus, is very great. 2d, its rays pass through glass with the greatest facility, (a property belonging to artificial heat in direct proportion to its intensity.) 3d, the brightness of the sun is greater than the most vivid flames, or the most intensely ignited solids.

## LESSON XIII.

### TRANSIT OF MERCURY AND VENUS.

*Question.* WHAT is the transit of a heavenly body?

*Answer.* It is its passage across the meridian.

*Q.* What is generally meant by the transit of Mercury and Venus?

*A.* It is their passage across the sun's disc.

*Q.* What is the disc of the sun or a planet?

*A.* It is the circular illuminated surface visible to us.

*Q.* How do Mercury and Venus appear, when passing across the sun's disc?

*A.* They appear like black spots moving across the sun.

*Q.* What proof have we that Mercury and Venus are not luminous bodies?

*A.* When viewed with the telescope they appear horned like the moon.

*Q.* On which side of the sun does a transit begin?

*A.* On the east side, and terminates on the west side.

### THE SPOTS ON THE SUN.

Astronomers do not agree, in all respects, as to the cause of the spots on the sun. From the facts already known, the following appears to be the most rational view of the subject The body of the sun, which is opake, is surrounded by a transparent atmosphere, in which float two strata of luminous clouds; the lower stratum being more dense and opake, and less luminous than the upper; while the latter, by its brilliancy, furnishes the greater portion of the intense light of the sun. Above the upper stratum, the transparent atmosphere extends to a great height. The agency by which the light and heat of the sun are generated, is not known. The only agent of which we know, that presents analogous phenomena, is electricity. The northern lights are supposed to exhibit, in a feeble manner, an action similar to the luminous strata of the sun. The polar regions of the sun are tranquil, and the equatorial comparatively so; but the surface on each side of the equator, from 15 to 25 degrees therefrom, is in a state of constant and violent agitation It is in this disturbed region that the spots are seen; no spot ever occurring farther than about 30 degrees from the equator. The spots, besides revolving with the sun, are found to have a motion from the equator towards the poles, and when they arrive at the comparatively calm region, they gradually disappear. Sometimes they close up with great rapidity, at others they appear to be suddenly broken into fragments and dispersed Bright spots and streaks, called faculæ, apparently caused by waves in the luminous portion of the atmosphere, also appear on various parts of the disc, but are seen most distinctly near the margin. In the places where spots appear, faculæ are usually seen on the day previous to their breaking out

But what causes the agitation of the sun's atmosphere, which is so great as frequently to burst open the luminous strata? Astronomers, at different times, have suggested various causes for the sun's spots, such as jets of gas issuing from the sun and decomposing the luminous clouds; high mountains, extending through the luminous strata; volcanoes, sending forth ashes, smoke, &c.; to say nothing of exploded theories of an older date, such as ashes, scoriæ, &c., on the surface of the melted, burning mass; or bodies very near the sun, revolving round it. But if we are permitted to reason from what takes place on the earth, we would say, that a close analogy exists between the phenomena observed in our own atmosphere and in that of the sun. On the earth the heat of the torrid zone causes the air to expand and rise, causing currents in the lower part of the atmosphere towards the equator, and in the upper part of the atmosphere currents towards the poles. The turning of the earth on its axis causes the under currents to take a westerly direction, while the upper currents sweep in a curve, westerly first, then towards the poles, and finally eastward. The principal disturbance of the atmosphere caused by the trade wind is in the vicinity of the tropics. Storms commencing in the torrid zone, are carried in the direction of the upper currents of air. For instance, a storm started in the West Indies, by the heating of the air over one of its islands, thus causing an upward and circular movement of the air, usually sweeps to the west and north over Florida, or the Gulf of Mexico, and then northeast, over the United States. Similar causes acting upon the atmosphere of the sun, would exhibit phenomena similar to those which we see. This explanation supposes the atmosphere of the sun to be warmer at the equator than at the poles; but as the sun does not, like the earth, receive its heat from any extraneous body, its difference of temperature must be sought for in the escape of its heat. It could attain this condition either by a more free radiation of heat at the poles than at the equator, or by its absorption as latent heat, in the evaporation from large bodies of water in the polar regions. As the sun turns on its axis, its equatorial diameter must be greater than its polar, and the stratum of atmosphere above the luminous clouds must be thicker over the equatorial region than over the polar. This must render the radiation less free at the equator than at the poles, and cause that part of the sun to be of a higher temperature. An excess of heat at the sun's equator, with its rotation on its axis, is sufficient to cause currents in its atmosphere similar to our trade winds, and thus disturb its equatorial regions; and if the spots are caused by storms bursting open the luminous strata, their receding from the equator towards the poles is undoubtedly the effect of the same physical causes that give a similar motion to storms upon the earth.

Some have supposed the body of the sun to be protected by the lower opake portion of the inner stratum of clouds, from the intense heat of the luminous strata, and thus rendered inhabitable; but several objections will at once arise to this theory. First, the body of the sun being surrounded by dense and opake clouds, could not send off its heat into space by radiation, and therefore the heat received from the clouds would accumulate and cause a high temperature. Second, the force of gravity being about thirty times as great as that of the earth, a common sized man would weigh some two or three tons; rendering it necessary to have an entirely different muscular organization. Third, it is improbable that living beings would be shut up within an impenetrable veil, and cut off from a knowledge of the planets, the stars, and the countless wonders existing in the boundless realms of space These and other considerations render it probable that the sun is not inhabited.


SIGNS OF THE ZODIAC
SEPTEMBER
AUTUMNAL EQUINOX
THE EARTH ENTERS ARIES 23RD SEP
AND AT THE SAME TIME THE SUN ENTERS
LIBRA
AUGUST
THE EARTH ENTERS PISCES 21ST AUG
AND AT THE SAME TIME THE SUN ENTERS
VIRGO
JULY
THE EARTH ENTERS AQUARIUS 23RD JULY
AND AT THE SAME TIME THE SUN ENTERS
LEO
JUNE
THE EARTH ENTERS CAPRICORNUS
21ST JUNE AND AT THE SAME TIME
THE SUN ENTERS
CANCER
MAY
THE EARTH ENTERS SAGITTARIUS
21ST MAY AND AT THE SAME TIME
THE SUN ENTERS
GEMINI
APRIL
THE EARTH ENTERS SCORPIO 20TH APRIL
AND AT THE SAME TIME THE SUN ENTERS
TAURUS
MARCH
VERNAL EQUINOX
THE EARTH ENTERS LIBRA 21ST MARCH
AND AT THE SAME TIME THE SUN ENTERS
ARIES
FEBRUARY
THE EARTH ENTERS VIRGO 19TH FEBRUARY
AND AT THE SAME TIME THE SUN ENTERS
PISCES
JANUARY
THE EARTH ENTERS LEO 20TH JANUARY
AND AT THE SAME TIME THE SUN ENTERS
AQUARIUS
DECEMBER
DECER SOLSTICE
WINTER CANCER 22D DEC.
THE EARTH ENTERS THE SAME TIME THE SUN ENTERS
AND AT THE CAPRICORNUS
NOVEMBER
THE EARTH ENTERS GEMINI
23D NOVR AND AT THE SAME TIME
THE SUN ENTERS
SAGITTARIUS
OCTOBER
THE EARTH ENTERS TAURUS
23D OCTOBER AND AT THE SAME TIME
THE SUN ENTERS
SCORPIO
ARIES
PISCES
EARTH'S ORBIT
AQUARIUS
CAPRICORNUS
SAGITTARIUS
SCORPIO
LIBRA
VIRGO
LEO
CANCER
GEMINI
TAURUS
AUTUMNAL EQUINOX
WINTER SOLSTICE
SUMMER SOLSTICE
VERNAL EQUINOX

## LESSON XIV.

### ZODIAC.

*Question.* WHAT is the Zodiac?

*Answer.* It is a circular belt in the heavens 16 degrees wide; 8 degrees on each side of the ecliptic.

*Q.* How is the zodiac divided?

*A.* It is divided into 12 equal parts, called signs or constellations of the zodiac.

*Q.* How is each sign divided?

*A.* Each sign is divided into 30 degrees; each degree into 60 minutes; each minute into 60 seconds, &c.

*Q.* What great circle is in the middle of the zodiac?

*A.* The ecliptic, or orbit of the earth.

*Q.* What are the names of the constellations of the zodiac and the signs of the ecliptic?

*A.* Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, and Pisces.

*Q.* Do the constellations of the zodiac and the signs of the ecliptic occupy the same places in the heavens?

*A.* They do not: the signs in the ecliptic have fallen back of the constellations about 31 degrees.

*Q.* Did the constellations of the zodiac and signs of the ecliptic ever correspond?

*A.* They corresponded to each other about 22 centuries ago.

*Q.* What is the cause of the falling back of the signs of the ecliptic among the constellations?

*A.* It is caused by the retrograde motion of the equinoxes. (NOTE.)

*Q.* Upon what does the length of the seasons depend?

*A.* They depend upon the revolution of the earth from one equinox to the same, again.

*Q.* Does the earth revolve around the sun in exactly the same time that it moves from one equinox to the same equinox again?

*A.* It moves from either equinox to the same again, seventeen minutes sooner, than around the sun.

## LESSON XV.

*Question.* DOES the sun appear to move in the heavens among the stars?

*Answer.* It has an apparent motion in the ecliptic, eastward around the heavens, during the year.

*Q.* How is this appearance caused, as the sun is in the centre, and does not move?

*A.* It is caused by the earth's moving around the sun.

*Q.* If the earth is in the sign Aries, where does the sun appear to be?

*A.* It appears to be in the opposite sign, *Libra*.

*Q.* As the earth moves around in the ecliptic, where does the sun appear to move?

*A.* It appears to move in the opposite part of the heavens, and in the opposite direction from the motion of the earth.

*Q.* Which sign does the sun enter, when the north pole leans exactly towards the sun?

*A.* Cancer. (21st June.)

*Q.* Which sign does the earth enter at this time?

*A.* Capricornus.

*Q.* Which signs does the sun enter, when the north pole leans sideways to the sun?

*A.* Aries and Libra.

*Q.* Which sign does the sun enter, when the north pole leans exactly from the sun?

*A.* Capricornus. (22d December.)

*Q.* Which are the equinoctial signs?

*A.* Aries, 21st of March—Libra, 23d of September.

*Q.* Which are the solstitial signs?

*A.* Cancer, 21st of June—Capricornus, 22d of December.

## LESSON XVI.

*Question.* How are the signs of the ecliptic divided?

*Answer.* They are divided into four divisions, corresponding to the seasons.

*Q.* Which are the spring signs?

*A.* Aries, Taurus, Gemini.

*Q.* Which are the summer signs?

*A.* Cancer, Leo, Virgo.

*Q.* Which are the autumnal signs?

*A.* Libra, Scorpio, Sagittarius.

*Q.* Which are the winter signs?

*A.* Capricornus, Aquarius, Pisces.

*Q.* In what time do the equinoxes fall back through the whole circle of the Zodiac?

*A.* 25,800 years.

*Q.* What is this time called?

*A.* The Platonic, or great year.

*Q.* How is this motion caused?

*A.* It is caused by a slow annual motion of the earth's axis. (NOTE.)

*Q.* What is longitude in the heavens?

*A.* It is the distance from the first degree of the sign Aries, reckoned eastward on the ecliptic, the whole circumference of the heavens.

*Q.* When the sun enters Aries, what is its longitude?

*A.* It has no longitude.

*Q.* What is the longitude of the earth at that time?

*A.* 180 degrees.

*Q.* When the sun enters Cancer, what is its longitude?

*A.* 90 degrees—the earth's longitude at the same time 270 degrees.

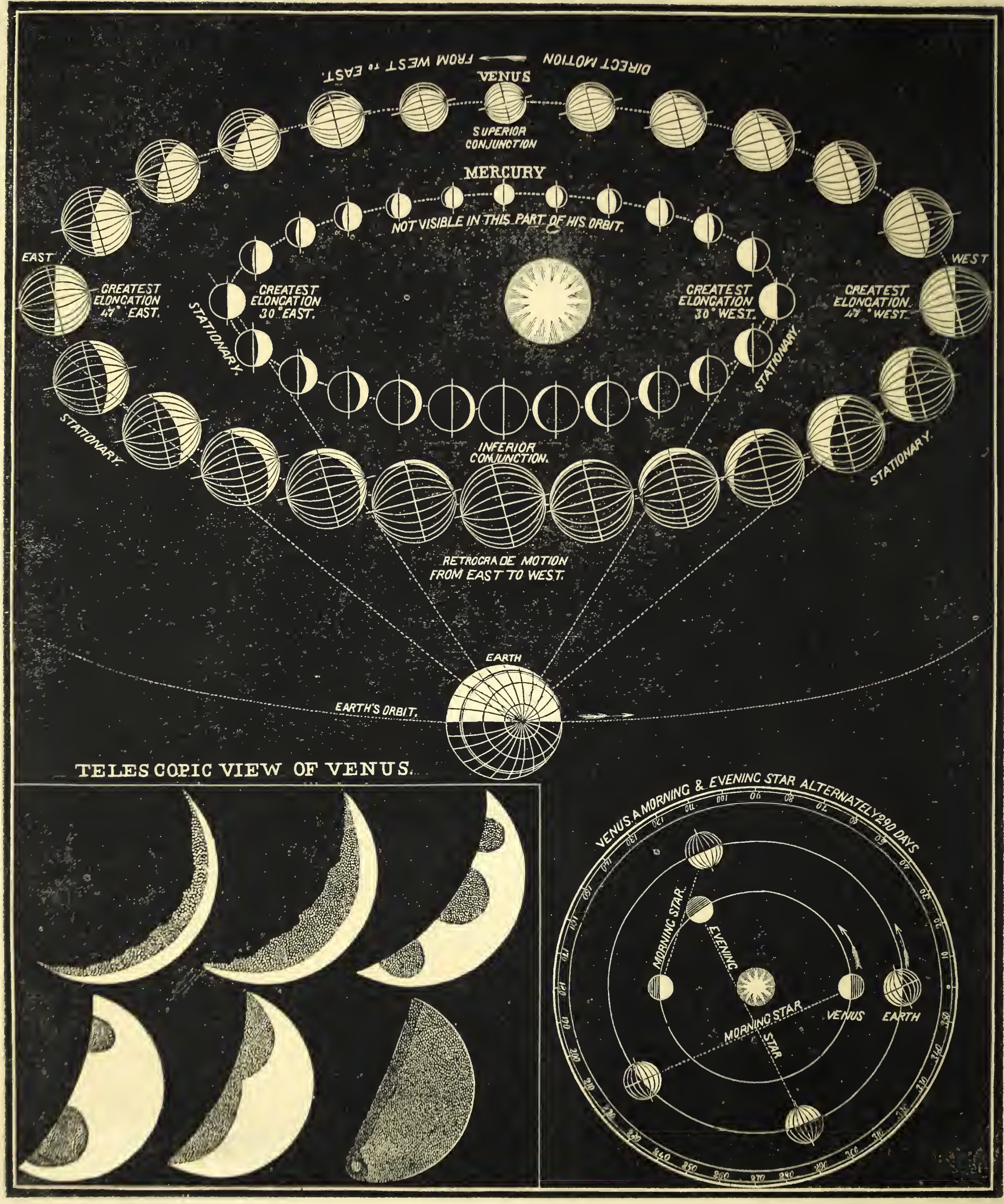
*Q.* When the sun enters Libra, what is its longitude?

*A.* 180 degrees—the earth's longitude 0 degrees.

*Q.* When the sun enters Capricornus, what is the longitude?

*A.* 270 degrees—the earth's longitude at the same time 90 degrees.

[NOTE.—This variation is caused by the pole of the earth varying a little every year. This motion of the pole of the earth is similar to that sometimes shown by a top, as it spins around on the point.—The stem of the top will have a circular motion, describing a cone with the apex or top down. This circular motion of the pole of the earth is very slow, varying only 50″ every year, and requires 25,868 years to complete a revolution—which is called the Platonic or great year. The pole of the earth is increasing its distance from the north star and in 12,900 years it will be about 47° from it; and when the north star is on the meridian, it will be in the zenith of the northern part of the United States: but in 25.800 years the pole will have made a complete revolution—so that it will point again to the north star.]


DIRECT MOTION FROM WEST to EAST.
VENUS
SUPERIOR CONJUNCTION
MERCURY
NOT VISIBLE IN THIS PART OF HIS ORBIT.
EAST
GREATEST ELONGATION 47° EAST.
GREATEST ELONGATION 30° EAST.
STATIONARY.
GREATEST ELONGATION 30° WEST.
STATIONARY.
GREATEST ELONGATION 47° WEST.
WEST
STATIONARY.
INFERIOR CONJUNCTION.
STATIONARY.
RETROGRADE MOTION FROM EAST TO WEST.
EARTH
EARTH'S ORBIT.
TELESCOPIC VIEW OF VENUS.
VENUS A MORNING & EVENING STAR ALTERNATELY 290 DAYS
MORNING STAR
EVENING
MORNING STAR
STAR
VENUS
EARTH

## LESSON XVII.

### MERCURY.

*Question.* Which planet is the smallest and nearest the sun?
*Answer.* Mercury.
*Q.* What is the diameter of Mercury?
*A.* 3,200 miles.
*Q.* What is its distance from the sun?
*A.* 37 millions of miles.
*Q.* What is its magnitude, compared with the earth?
*A.* It is $\frac{1}{17}$ of the earth's magnitude.
*Q.* What is the specific gravity of the planet Mercury?
*A.* It is about 15 times the weight of water. (15.111.)
*Q.* In what time does it revolve on its axis, or perform its daily revolution?
*A.* In about 24 hours. (24 hours 5 minutes.)
*Q.* In what time does it revolve around the sun?
*A.* In about 88 days. (87d. 23h. 14m. 33s.)
*Q.* How fast does it move in its orbit around the sun?
*A.* It moves 112,000 miles an hour.
*Q.* What is the light or heat at Mercury, compared with that of the earth?
*A.* It is about seven times as great.
*Q.* What is elongation?
*A.* It is the apparent distance of any planet from the sun.
*Q.* What is the greatest elongation of Mercury?
*A.* 30 degrees; which may be either east or west of the sun.
*Q.* Why is Mercury never seen in superior conjunction?
*A.* Because it is so much involved in the light of the sun.
*Q.* Does Mercury experience any change of seasons?
*A.* It does not, because its axis is perpendicular to its orbit. This causes the sun to be continually vertical at the equator.

## LESSON XVIII.

### VENUS.

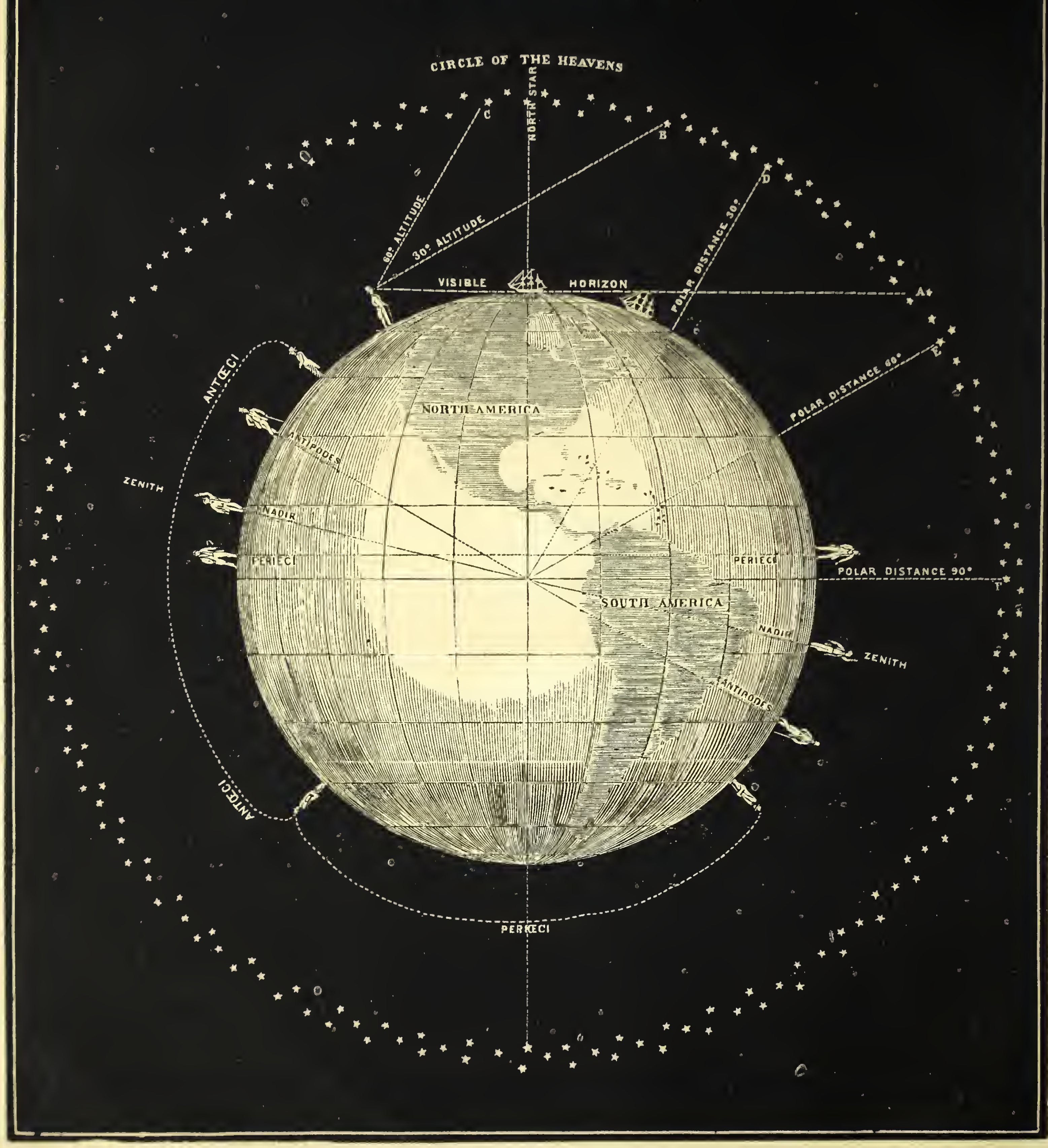
*Question.* What planet is next to Mercury?
*Answer.* Venus.
*Q.* What is the diameter of Venus?
*A.* 7,700 miles.
*Q.* What is its distance from the sun
*A.* 68 millions of miles.
*Q.* What is its magnitude compared with the earth?
*A.* It is about $\frac{9}{10}$ of the earth's magnitude.
*Q.* What is the specific gravity of Venus?
*A.* It is 5 times the weight of water. (5.058.)
*Q.* In what time does it revolve on its axis?
*A.* In about 23½ hours. (23h. 21m.)
*Q.* In what time does it revolve around the sun?
*A.* In 224 days. (224d. 16h. 41m. 27s.)
*Q.* How fast does it move in its orbit around the sun?
*A.* It moves 75,000 miles an hour.
*Q.* What is the comparative light or heat at Venus?
*A.* It is about double that of the earth.
*Q.* What is the greatest elongation of Venus?
*A.* About 47 degrees.
*Q.* When is Venus a morning star?
*A.* When it is west of the sun, and rises before it.
*Q.* When is it an evening star?
*A.* When it is east of the sun, and sets after it.
*Q.* How long is Venus a morning or an evening star, alternately?
*A.* About 290 days.
*Q.* Why is Venus a morning or an evening star 66 days longer than the time of its revolution around the sun?
*A.* Because the earth is moving around the sun the same way.

[See diagram. If we suppose Venus to be in conjunction, or between the earth and sun, as they move the same way, Venus will move half around the sun, or 180 degrees, while the earth moves only 110 degrees. Venus will during this time be a morning star, and when Venus has completed its revolution around the sun, the earth will have passed through 220 degrees of its orbit, and Venus will still continue a morning star, although it has made a complete revolution around the sun. It will therefore have to make one complete revolution and 103 degrees over, before it can be seen on the other side of the sun; it will then be an evening star for the same length of time.]

## LESSON XIX.

*Question.* How much is the axis of Venus inclined to that of its orbit?
*Answer.* 75 degrees.
*Q.* When the north pole of Venus inclines directly towards the sun, how many degrees will the axis point above the sun?
*A.* Only 15 degrees.
*Q.* How wide a torrid zone does this make?
*A.* 150 degrees—75 degrees on each side of the equator.
*Q.* The tropics are within how many degrees of the poles?
*A.* Within 15 degrees.
*Q.* The polar circles are within how many degrees of the equator?
*A.* 15 degrees.
*Q.* What is the diameter of the polar circles?
*A.* 150 degrees.
*Q.* Has Venus any variation of seasons?
*A.* She has two summers and two winters at the equator, and a summer and winter at each of the poles, during the year.
*Q.* How does Venus appear when viewed with a telescope?
*A.* She exhibits phases similar to those of the moon.
*Q.* How are conjunctions divided?
*A.* Into inferior and superior.
*Q.* When is a planet in inferior conjunction?
*A.* When it is between the earth and sun.
*Q.* What planets have inferior conjunction?
*A.* Mercury and Venus; also the moon.
*Q.* When is a planet in superior conjunction?
*A.* When it is beyond the sun.
*Q.* What planets have superior conjunction?
*A.* All, except the earth.
*Q.* When is a planet in opposition to the sun?
*A.* When it is on the opposite side of the earth.
*Q.* What planets have opposition?
*A.* The superior planets.
*Q.* What apparent motions have the planets?
*A.* Three; direct, stationary, and retrograde.
*Q.* When does a planet's motion appear to be direct?
*A.* When it appears to move from west to east among the stars.
*Q.* When is a planet's motion said to be stationary?
*A.* When it is moving directly towards or from the earth.
*Q.* When is a planet's motion said to be retrograde?
*A.* When it appears to move backwards, or from east to west among the stars.

# DEFINITIONS



## LESSON XX.

### EARTH, DEFINITIONS, &c.

*Question.* WHAT is the shape of the earth?

*Answer.* It is round like a globe or ball, a little flattened at the poles.

*Q.* How do we know the earth to be round?

*A.* 1st. Navigators have sailed round it, by a continued westerly or easterly course.—2d. The top-mast of a ship coming in from the sea, always appears first.—3d. The earth's shadow upon the moon, in a lunar eclipse, is circular.

*Q.* In what manner do the inhabitants stand upon the earth?

*A.* They stand with their feet directed towards the centre of the earth. (See Diagram.)

*Q.* What do you understand by the terms upward and downward?

*A.* Upward is from the centre of the earth, downward is towards the centre of the earth.

*Q.* What keeps the inhabitants, &c., upon the surface of the earth?

*A.* The attraction of the earth.

*Q.* What is the axis of the earth?

*A.* It is the straight line round which it performs its daily revolution.

*Q.* What are the poles of the earth?

*A.* They are the extremities of its axis.

*Q.* What is the equator?

*A.* It is a great circle, whose plane divides the earth into northern and southern hemispheres.

*Q.* To what is the plane of the equator perpendicular?

*A.* It is perpendicular to the earth's axis, and equidistant from the poles.

*Q.* What is the meridian of a place on the earth?

*A.* It is a great circle passing through the place, and the poles of the earth.

*Q.* Into what does the plane of the meridian divide the earth?

*A.* Into eastern and western hemispheres.

*Q.* What is the latitude of a place on the earth?

*A.* It is its distance from the equator, north or south.

*Q.* On what is it measured?

*A.* On a meridian?

*Q.* How far is latitude reckoned?

*A.* Ninety degrees?

*Q.* What places have 90 degrees of latitude?

*A.* The poles.

## LESSON XXI.

*Q.* Which is the first meridian?

*A.* It is the meridian from which longitude is reckoned.

*Q.* Which meridian is generally used in this country as the first meridian?

*A.* The meridian of London.

*Q.* What is the longitude of a place on the earth?

*A.* It is its distance east or west of the first meridian.

*Q.* What angle expresses the longitude of a place?

*A.* The angle between the meridian of the place, and the first meridian.

*Q.* Where is this angle formed?

*A.* At the poles, where the meridians intersect each other.

*Q.* On what circle is this angle measured?

*A.* On the equator.

*Q.* How far is terrestrial longitude reckoned?

*A.* It is reckoned 180 degrees, or half round the earth.

*Q.* What is the horizon?

*A.* It is a great circle which separates the visible heavens from the invisible.

*Q.* How many horizons are there?

*A.* Two; the visible and the rational.

*Q.* What is the visible or sensible horizon?

*A.* It is that circle where the earth and sky appear to meet.

*Q.* What is the rational horizon?

*A.* It is a great circle, parallel to the visible horizon, whose plane passes through the centre of the earth.

*Q.* Into what does it divide the earth?

*A.* Into upper and lower hemispheres.

*Q.* Is the rational horizon above or below the visible horizon?

*A.* It is below the visible horizon.

## LESSON XXII.

*Q.* Do all places on the earth have the same horizon?

*A.* They do not; if we change our place on the earth, the horizon changes.

*Q.* What are the poles of the horizon?

*A.* The zenith and nadir.

*Q.* What is the zenith?

*A.* It is that point in the heavens directly over our heads.

*Q.* Do all places have the same zenith?

*A.* They do not; every place has a different zenith.

*Q.* What is the nadir?

*A.* It is that point in the heavens which is opposite to the zenith, or directly under our feet.

*Q.* Are the zenith and nadir fixed points in the heavens?

*A.* They are not; they make a complete revolution in the heavens every 24 hours.

*Q.* What is the altitude of a heavenly body?

*A.* It is its height or distance from the horizon.

*Q.* What is the altitude of the star at A? (See Diagram.)

*A.* It has no altitude, being in the horizon.

*Q.* What is the altitude of the star at B? also at C? (See Diagram.)

*Q.* What is the polar distance of a heavenly body?

*A.* It is its distance from the pole.

Q. What is the polar distance of the star at D? also at E. and F? (See Diagram.)

*Q.* Who are the antipodes?

*A.* Those who live on directly opposite sides of the earth.

*Q.* Who are the antœci?

*A.* Those who live in equal latitude, on directly opposite sides of the equator.

*Q.* Who are the periœci?

*A.* Those who live in equal latitude on opposite sides of the pole.

*Q.* What peculiarity of circumstances have the antipodes?

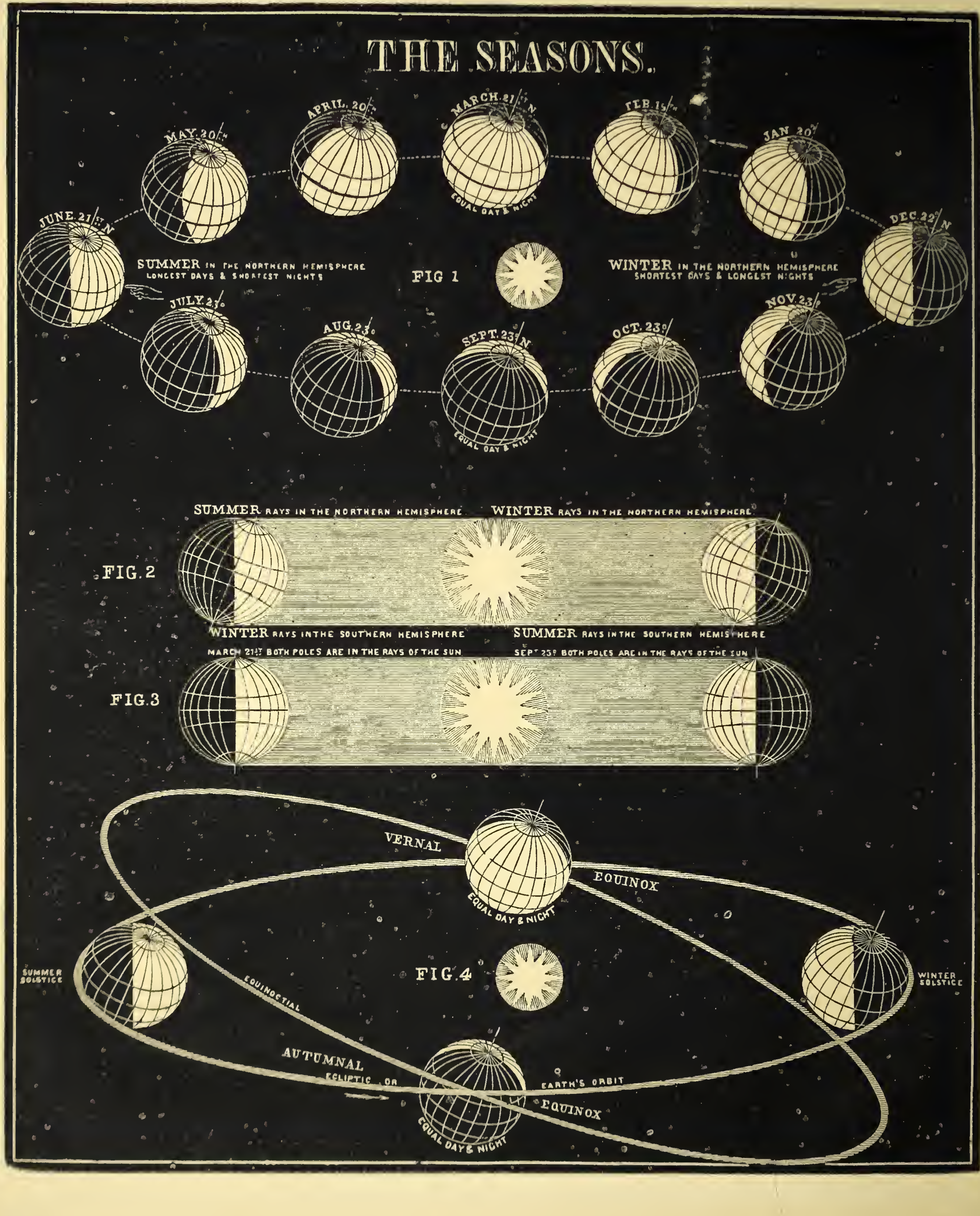
*A.* They have opposite latitude, seasons, longitude, and day and night.

*Q.* What have the antœci?

*A.* They have opposite latitude and seasons, but the same longitude, and day and night.

*Q.* What have the periœci?

*A.* They have the same latitude and seasons, but opposite longitude, and day and night.


THE SEASONS.
APRIL. 20TH
MARCH.21ST N
FEB.15TH
MAY.20TH
JAN 20TH
EQUAL DAY & NIGHT
JUNE.21ST N
DEC.22D N
SUMMER IN THE NORTHERN HEMISPHERE
LONGEST DAYS & SHORTEST NIGHTS
FIG 1
WINTER IN THE NORTHERN HEMISPHERE
SHORTEST DAYS & LONGEST NIGHTS
JULY.23D
NOV.23D
AUG.23D
SEPT.23D N
OCT.23D
EQUAL DAY & NIGHT
SUMMER RAYS IN THE NORTHERN HEMISPHERE
WINTER RAYS IN THE NORTHERN HEMISPHERE
FIG.2
WINTER RAYS IN THE SOUTHERN HEMISPHERE
SUMMER RAYS IN THE SOUTHERN HEMISPHERE
MARCH 21ST BOTH POLES ARE IN THE RAYS OF THE SUN
SEPT 23D BOTH POLES ARE IN THE RAYS OF THE SUN
FIG.3
VERNAL
EQUINOX
EQUAL DAY & NIGHT
SUMMER SOLSTICE
FIG.4
WINTER SOLSTICE
EQUINOCTIAL
AUTUMNAL
ECLIPTIC OR
EARTH'S ORBIT
EQUINOX
EQUAL DAY & NIGHT

## LESSON XXIII.

### EARTH AND SEASONS.

*Question.* WHAT is the shape of the earth?

*Answer.* It is round like a globe or ball, a little flattened at the poles

*Q.* What is its position in the solar system?

*A.* It is the third planet from the sun.

*Q.* What is the mean diameter of the earth?

*A.* 7,912 miles. [Equatorial diameter 7,926 miles; polar diameter 7,899 miles.)

*Q.* How much greater is the equatorial than the polar diameter?

*A.* About 27 miles.

*Q.* What causes the equatorial diameter to be greater than the polar?

*A.* It is caused by the revolution of the earth on its axis.

[As the greater portion of the surface of the earth is covered with water; and as the earth revolves on its axis, the water recedes from the poles towards the equator, until its tendency to run back towards the poles, just balances the effects of the centrifugal force. This causes the equatorial diameter to be greater than the polar. If the earth should stop revolving on its axis, the water at the equator would settle away towards the poles, until the earth had assumed the form of a globe as near as possible. Thus large portions of land in the torrid zone, which are now covered by the ocean, would be left dry, and new continents and islands would be formed.]

*Q.* What is the mean distance of the earth from the sun?

*A.* About 95,000,000 of miles.

[The mean distance of a planet, is the distance it would always be from the sun, if its orbit should be reduced to a true circle.]

*Q.* What is the specific gravity of the earth?

*A.* It is $5\frac{1}{2}$ times the weight of water. (5.48.)

*Q.* In what time does the earth revolve on its axis, or perform its diurnal revolution?

*A.* In 24 hours. (In 23 hours 56 minutes; as seen from the stars.)

*Q.* Which way does it revolve?

*A.* From west to east.

*Q.* What causes day and night?

*A.* The light of the sun causes day, and the shade of the earth causes night.

*Q.* How great a portion of the earth is continually in the light of the sun?

*A.* One half; the other half being in the shade of the earth.

Q. What does the revolution of the earth upon its axis, cause?

*A.* The succession of day and night.

## LESSON XXIV.

*Question.* As the earth turns upon its axis, what effect is produced?

*Answer.* The sun is continually rising to places in the west, and continually setting to places in the east.

*Q.* In what time does the earth revolve around the sun, or perform its annual revolution?

*A.* In 365 days 6 hours.

*Q.* How fast does it move in its orbit around the sun?

*A.* 68,000 miles an hour.

*Q.* How are the changes of the seasons caused?

*A.* They are caused by the earth's axis being inclined to that of its orbit, and its revolution around the sun.

*Q.* How many degrees is the earth's axis inclined towards its orbit?

*A.* Twenty-three degrees and a half. (23° 28′.)

*Q.* Is the direction of the earth's axis changed during the year?

*A.* Its change is so slight that it may be considered as pointing to the same place in the heavens.

*Q.* When does the north pole lean directly towards the sun?

*A.* On the 21st of June, called the summer solstice. (See Diagram.)

*Q.* How many degrees does it lean towards the sun?

*A.* $23\frac{1}{2}$ degrees; and the sun is vertical $23\frac{1}{2}$ degrees north of the equator.

Q. What seasons does this produce?

*A.* Summer in the northern hemisphere, and winter in the southern.

Q. When does the north pole lean directly from the sun?

*A.* On the 22d of December, called the winter solstice. (See Diagram.)

*Q.* When the north pole leans from the sun, what are the seasons?

*A.* Winter in the northern hemisphere, and summer in the southern.

## LESSON XXV.

*Question.* At what points of the ecliptic is the earth at the time of the solstices?

*A.* At the solstitial points.

*Q.* Through how much of its orbit does the earth pass, in moving from one solstitial point to the other?

*A.* One half of its orbit, or from one side of the sun to the other.

*Q.* What are those two points called half way between the solstitial points?

*A.* The equinoctial points. (See Diagram.)

*Q.* Why are they so called?

*A.* Because, when the earth is in these points, the sun is vertical at the equator, and the days and nights are every where equal.

*Q.* When is the sun at the vernal equinox?

*A.* On the 21st of March.

*Q.* When is it at the autumnal equinox?

*A.* On the 23d of September.

*Q.* Which way does the pole lean when the earth is at the equinoctial points?

*A.* It leans sideways to the sun, the sun being vertical at the equator.

*Q.* When the north pole leans towards the sun, why is summer produced in the northern hemisphere?

*A.* Because the rays of the sun strike it so directly as to cause many rays to fall on a given surface.

*Q.* When the north pole leans from the sun, why is winter produced in the northern hemisphere?

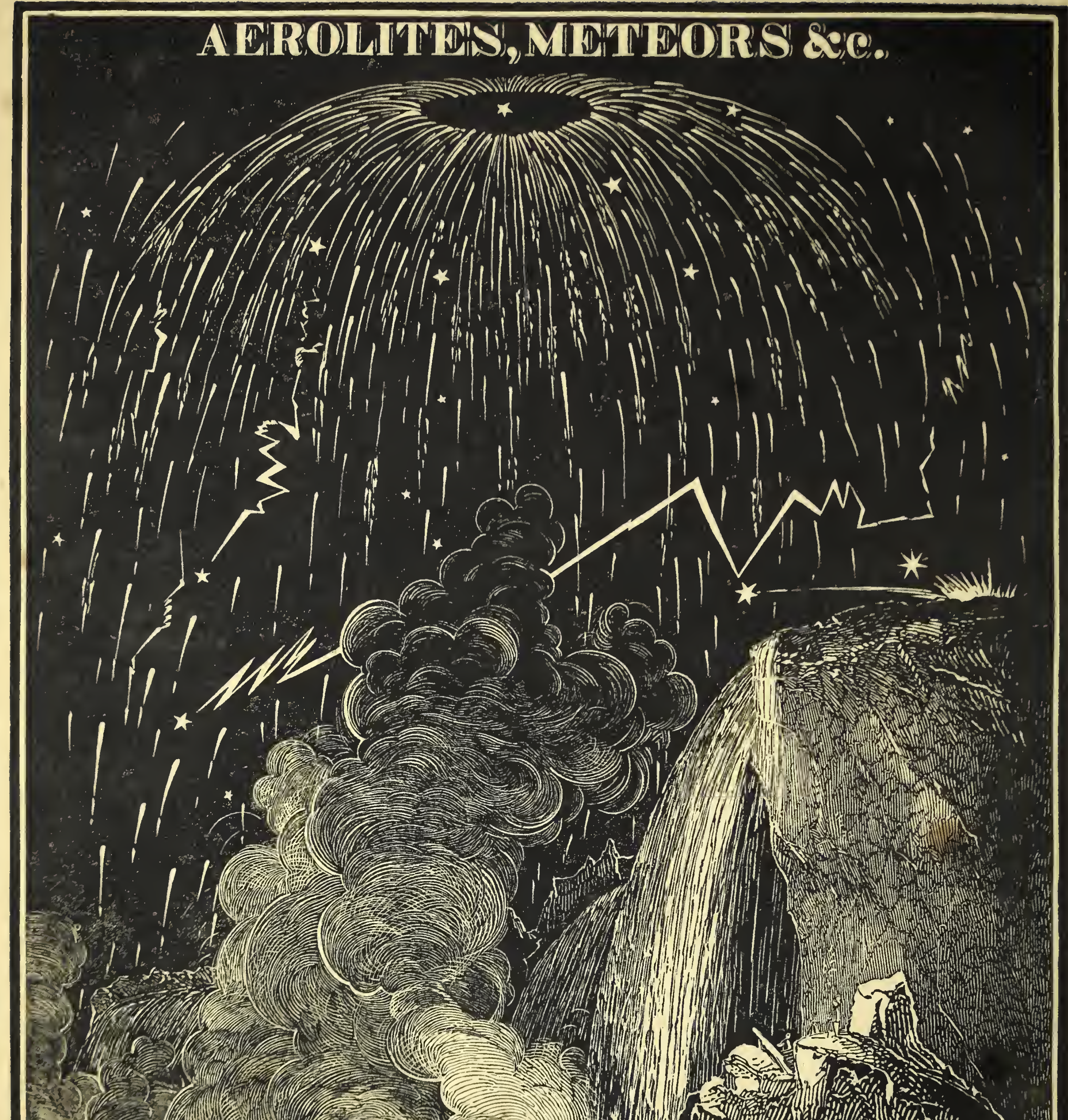
*A.* Because the rays of the sun strike it so obliquely, that they spread over a greater surface.

*Q.* At what points do the ecliptic and equinoctial intersect each other?

*A.* At the equinoctial points. (See Diagram.)

*Q.* How far are the solstitial points from the equinoctial points?

*A.* Ninety degrees.



AEROLITES, METEORS &c.

## AËROLITES, METEORS, &c.

*Question.* What are meteors?

*Answer.* They are luminous bodies seen in the night shooting through the heavens.

*Q.* What are they usually called?

*A.* *Shooting stars*, and sometimes fire-balls.

*Q.* What is an aërolite?

*A.* It is a stone falling from the air.

*Q.* Have stones ever been known to fall from the air?

*A.* They have, and in great numbers. (See Table.)

*Q.* How did Laplace, Olbers, and other astronomers account for the falling of these stones?

*A.* They believed that they were ejected from volcanos in the moon, beyond the moon's attraction, and therefore attracted to the earth.

*Q.* How did they account for the *meteors?*

*A.* They believed them to be gaseous matter collected in the upper regions, and ignited by some unknown cause.

*Q.* What is the present theory in regard to aërolites and meteors?

*A.* Astronomers believe that they have the same origin.

*Q.* Do all meteors produce stones which fall to the earth?

*A.* They do not; very few of them are of sufficient density to reach the earth before they are consumed.

*Q.* Do these meteors originate in our atmosphere?

*A.* The most of them have their origin far beyond our atmosphere.

*Q.* What is the present theory of meteors?

*A.* Astronomers maintain that the planetary regions contain detached portions of chaotic and uncondensed matter, and that the earth in its orbit frequently meets with such masses.

*Q.* What effect would be produced by such contact?

*A.* The matter in its passage through the atmosphere would suddenly be ignited and the gaseous portion consumed, and the mineral portion, if any, would be condensed and precipitated to the earth in the form of a stone.

*Q.* What is a peculiar characteristic of meteoric stones?

*A.* They are composed of the same materials and nearly in the same proportions, and are unlike any combination of minerals found on the earth.

*Q.* What does this fact prove?

*A.* It conclusively proves that they have a common origin.

*Q.* When was the greatest meteoric display ever known? (See Note 2.)

*A.* On the night of the 12th and 13th of November, 1833.

*Q.* What was the altitude of the meteors on this occasion?

*A.* *Professor* Olmstead says they were not less than 2238 miles above the earth.

| *Substance.* | *Place.* | *Period.* |
|---|---|---|
| Shower of stones | At Romo | Under Tullus Hostilius. |
| Shower of stones | At Romo | Consuls C. Martius and Torquatus. |
| Shower of iron | In Lucania | Year before the defeat of Crassus. |
| Shower of mercury | In Italy | |
| Large stone | Near the river Negos, Thrace | Second year of the 78th Olympiad. |
| Three large stones | In Thrace | Year before J. C. 452. |
| Shower of fire | At Quesnoy | January 4, 1717. |
| Stone of 72 lbs. | Near Larissa, Macedonia | January, 1706. |
| About 1200 stones—one of 120 lbs, another of 60 lbs. | Near Padua, Italy | In 1510. |
| Another of 59 lbs. | On Mount Vasier, Province | November 27, 1627. |
| Shower of Sand for 15 hours | In the Atlantic | April 6, 1719. |
| Shower of sulphur | Sodom and Gomorra | |
| Sulphurous rain | In the Duchy of Mansfield | In 1658. |
| The same | Copenhagen | In 1646. |
| Shower of sulphur | Brunswick | October, 1721. |
| Shower of unknown matter | Ireland | In 1695. |
| Two large stones, weighing 20 lbs. | Liponas, in Bresse | September, 1753. |
| A stony mass | Niort, Normandy | In 1750. |
| A stone of 7 1-2 lbs. | At Luce, in Le Maino | September 13, 1768 |
| A stone | At Aire, in Artois | In 1768. |
| A stone | In Le Cotentin | In 1768. |
| Extensive shower of stones | Environs of Agen | July 24, 1790. |
| About 12 stones | Sienna, Tuscany | July, 1794. |
| A large stone of 56 lbs. | Wold Cottage, Yorkshire | December 13, 1795. |
| A stone of about 20 lbs. | Sale, Department of the Rhone | March 17, 1768. |
| A stone of 10 lbs. | In Portugal | February 19, 1796. |
| Shower of stones | Benares, East Indies | December 19, 1798 |
| Shower of stones | At Plann, near Tabor, Bohemia | July 3, 1753. |
| Mass of iron, 70 cubic feet | America | April 5, 1800 |
| Mass of iron, 14 quintals | Abakauk, Siberia | Very old. |
| Shower of stones | Barboutan, near Roquefort | July, 1789. |
| Large stone of 260 lbs. | Ensisheim, Upper Rhine | November 7, 1492. |
| Two stones, 200 and 300 lbs. | Near Verona | In 1762. |
| A stone of 20 lbs. | Sules, near Ville Franche | March 12, 1798 |
| Several stones from 10 to 17 lbs. | Near L'Aigle, Normandy | April 26, 1803. |

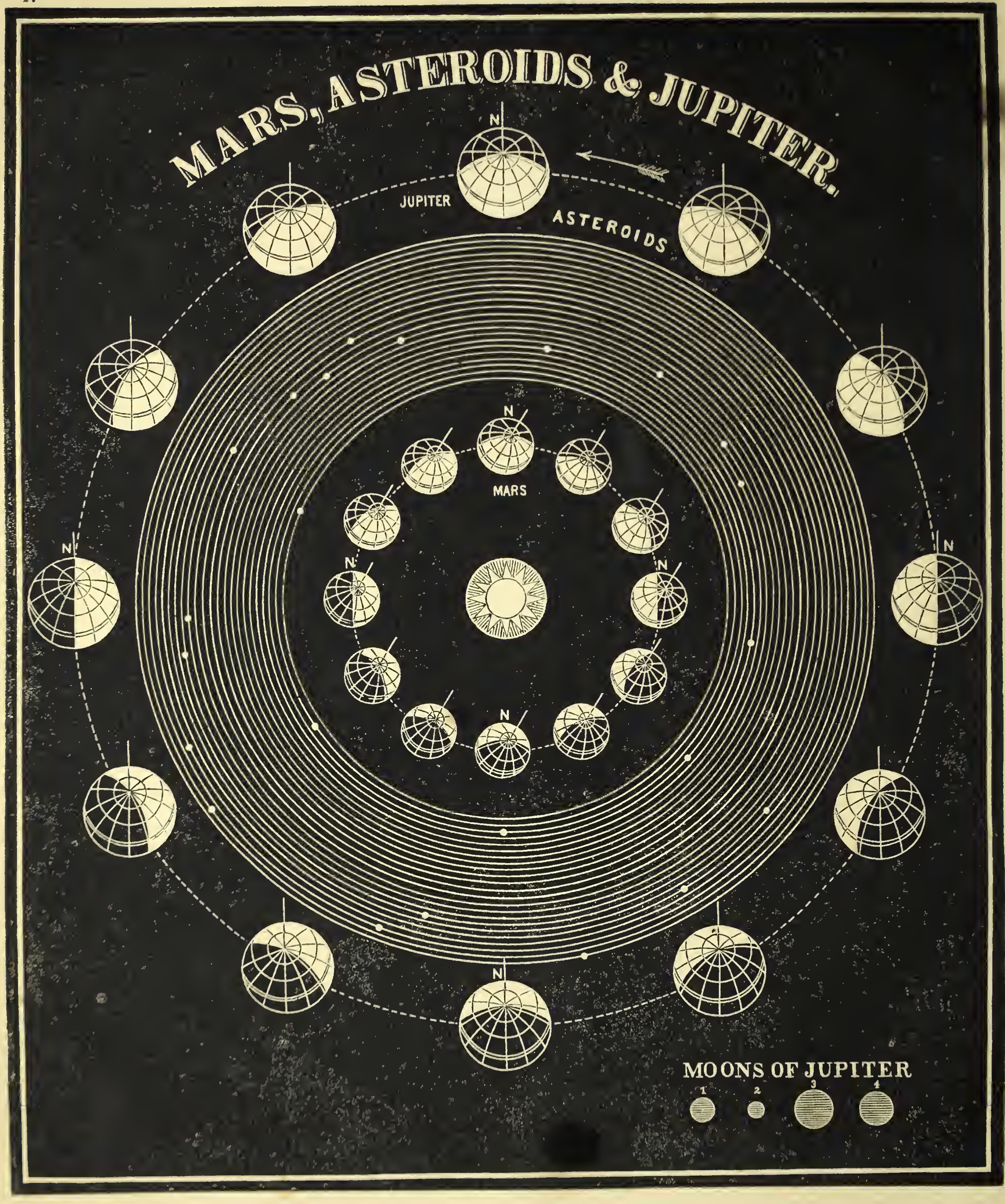
### NOTE.

One of the instances in the table is of sufficient interest to deserve a notice.

A singular relation respecting the stone of Ensisheim on the Rhine, (at which philosophy once smiled incredulously, regarding it as one of the romances of the middle ages,) may now be admitted to sober attention as a piece of authentic history. A homely narrative of its fall was drawn up at the time by order of the emperor Maximilian, and deposited with the stone in the church. It may thus be rendered :—"In the year of the Lord 1492, on Wednesday, which was Martinmas eve, the 7th of November, a singular miracle occurred; for, between eleven o'clock and noon, there was a loud clap of thunder and a prolonged confused noise, which was heard at a great distance; and a stone fell from the air, in the jurisdiction of Ensisheim, which weighed two hundred and sixty pounds, and the confused noise was, besides, much louder than here. Then a child saw it strike on a field in the upper jurisdiction, towards the Rhine and Inn, near the district of Giscano, which was sown with wheat, and it did it no harm, except that it made a hole there; and then they conveyed it from that spot; and many pieces were broken from it, which the landvogt forbade. They, therefore, caused it to be placed in the church, with the intention of suspending it as a miracle: and there came here many people to see this stone. So there were remarkable conversations about this stone: but the learned said that they knew not what it was; for it was beyond the ordinary course of nature that such a large stone should smite the earth from the height of the air; but that it was really a miracle of God; for, before that time, never anything was heard like it, nor seen, nor described. When they found that stone, it had entered into the earth to the depth of a man's stature, which every body explained to be the will of God that it should be found; and the noise of it was heard at Lucerne, at Vitting, and in many other places, so loud that it was believed that houses had been overturned: and as the King Maximilian was here the Monday after St. Catharine's day of the same year, his royal Excellency ordered the stone which had fallen to be brought to the Castle, and, after having conversed a long time about it with the noblemen, he said that the people of Ensisheim should take it, and order it to be hung up in the church, and not to allow any body to take anything from it. His Excellency, however, took two pieces of it; of which he kept one, and sent the other to the Duke Sigismund of Austria: and they spoke a great deal about this stone, which they suspended in the choir, where it still is; and a great many people came to see it." Contemporary writers confirm the substance of this narration, and the evidence of the fact exists; this aërolite is precisely identical in its chemical composition with that of other meteoric stones. It remained for three centuries suspended in the church, was carried off to Colmar during the French revolution; but has since been restored to its former site, and Ensisheim rejoices in the possession of the relic.

### NOTE 2.

We now come to by far the most splendid display on record; and as it was the third in successive years, and on the same day of the month, it seemed to invest the meteoric showers with a periodical character; and hence originated the title of November meteors. An incessant play of dazzlingly brilliant meteors was kept up in the heavens for several hours. Some of these were of considerable magnitude and peculiar form. One of large size remained for some time almost stationary in the zenith, over the Falls of Niagara, emitting streams of light. The wild dash of the waters, as contrasted with the fiery uproar above them, formed a scene of unequalled sublimity. In many districts, the mass of the population were terror-struck, and the more enlightened were awed at contemplating so vivid a picture of the Apocalyptic image—that of the stars of heaven falling to the earth, even as a fig-tree casting her untimely figs, when she is shaken of a mighty wind. A planter of South Carolina thus describes the effect of the scene upon the ignorant blacks:—"I was suddenly awakened by the most distressing cries that ever fell on my ears. Shrieks of horror and cries for mercy I could hear from most of the negroes of three plantations, amounting in all to about six or eight hundred. While earnestly listening for the cause, I heard a faint voice near the door calling my name. I arose, and taking my sword, stood at the door. At this moment, I heard the same voice still beseeching me to rise, and saying 'O my God, the world is on fire.' I then opened the door, and it is difficult to say which excited me most—the awfulness of the scene, or the distressed cries of the negroes. Upwards of one hundred lay prostrate on the ground—some speechless, and some with the bitterest cries, but with their hands raised, imploring God to save the world and them. The scene was truly awful; for never did rain fall much thicker than the meteors fell towards the earth; east, west, north and south, it was the same."


MARS, ASTEROIDS & JUPITER.
N
JUPITER
ASTEROIDS
MARS
N
N
N
N
N
N
MOONS OF JUPITER
1
2
3
4

## LESSON XXVI.

### MARS.

*Question.* WHAT is Mars?

*Answer.* Mars is the fourth planet from the sun.

*Q.* What can you say of its size?

*A.* It is the smallest except Mercury and the asteroids.

*Q.* What is its diameter?

*A.* 4,189 miles.

*Q.* What is its distance from the sun?

*A.* 142 millions of miles.

*Q.* What is its magnitude?

*A.* It is about one seventh of the size of the earth.

*Q.* What is the specific gravity of Mars?

*A.* It is about five times the weight of water. (5.19.)

*Q.* In what time does it revolve on its axis?

*A.* In about 24½ hours. (24h. 39m. 22s.)

*Q.* In what time does it revolve around the sun?

*A.* In one year, 321 days.

*Q.* How fast does it move in its orbit?

*A.* 55,000 miles an hour.

*Q.* How many degrees does the axis of Mars lean towards its orbit?

*A.* About 30 degrees, (30° 18′.) (See Diagram.)

*Q.* Does Mars have any change of seasons?

*A.* The seasons are similar to those of the earth, but nearly twice as long.

*Q.* Why are they longer?

*A.* Because Mars is nearly two of our years in revolving around the sun.

*Q.* What is the appearance of Mars when seen with the naked eye?

*A.* It appears of a red, fiery color.

## LESSON XXVII.

*Q.* How does Mars appear when viewed with a telescope?

*A.* Outlines of apparent continents and seas, are distinctly seen.

*Q.* What appearance have the continents?

*A.* They have a ruddy color, arising probably from the nature of the soil.

*Q.* Of what color are the seas?

*A.* They appear of a greenish color, caused no doubt by contrast with the red color of the continents.

*Q.* Does Mars present different phases?

*A.* It sometimes appears gibbous.

*Q.* When does a planet appear gibbous?

*A.* When we can see more than half, but not the whole, of the illuminated surface.

*Q.* Does Mars ever appear horned like the moon?

*A.* It does not, because it does not pass between us and the sun.

*Q.* What other appearances does Mars exhibit when viewed with a telescope?

*A.* Bright spots are seen alternately at the poles.

*Q.* When do these spots appear?

*A.* When it is winter, or continual night at the poles.

*Q.* What is supposed to be the cause of these spots?

*A.* Snow and ice, which has accumulated at the poles during winter.

*Q.* Do these spots continue through the year?

*A.* They entirely disappear as the summer advances upon the poles.

*Q.* What amount of light and heat has Mars?

*A.* It has about half as much as the earth.

### ASTEROIDS.

*Question.* WHAT are the *asteroids?*

*Answer.* They are small bodies between the orbits of Mars and Jupiter.

*Q.* How many are there?

*A.* Twenty three is the number known at present.

*Q.* What is their magnitude?

*A.* They are very small with the exception of Pallas.

*Q.* What have some astronomers supposed in regard to them?

*A.* That they were once united in one planet; but blown to pieces by some internal explosion.

*Q.* What facts do they advance to prove this theory?

*A.* They are rough with sharp angular points.

#### NOTE.

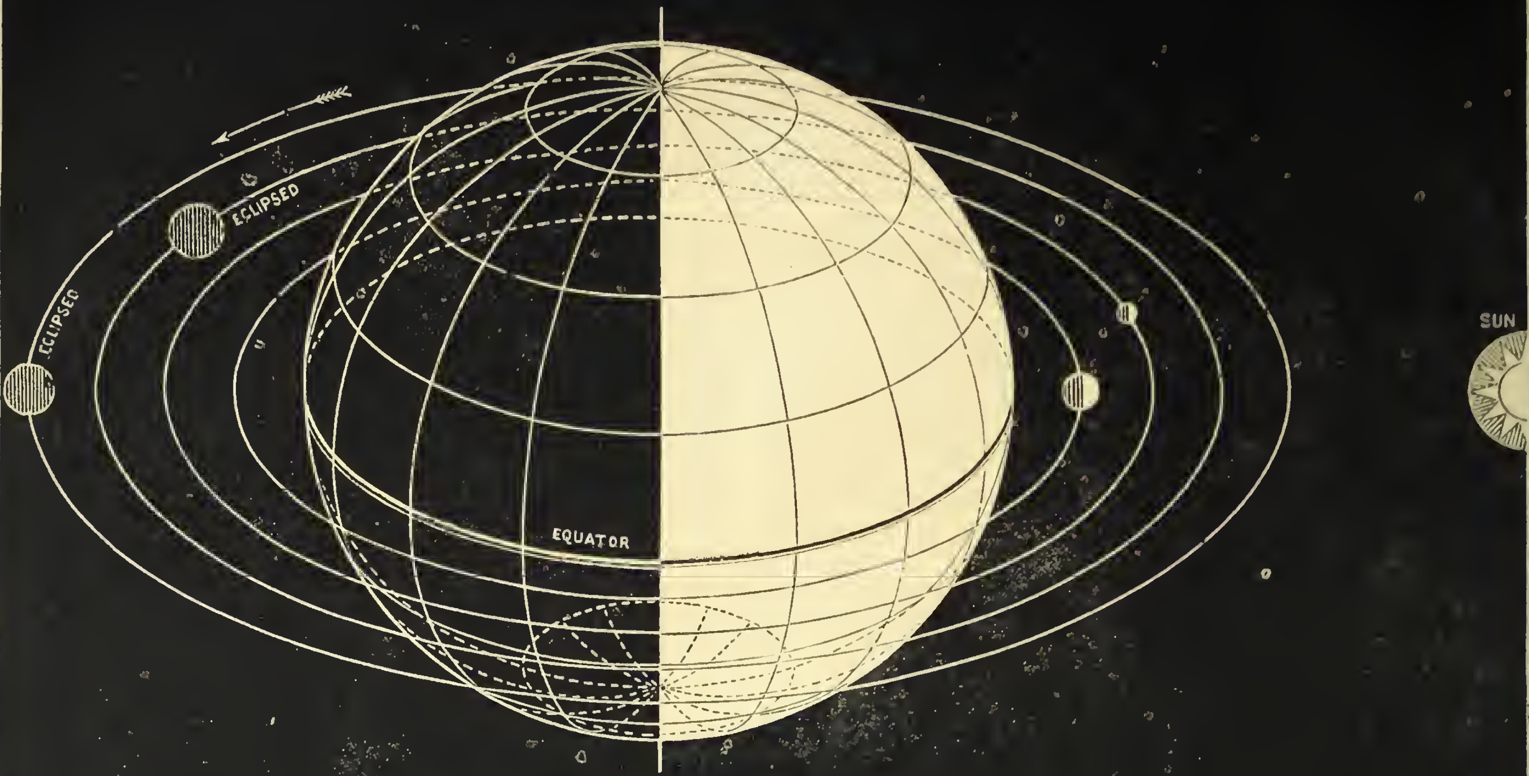
Astronomers in comparing the distances of the planets, found that there was a great distance between Mars and Jupiter which did not coincide with the uniformity exhibited by the other planets. This led them to suspect that there was an undiscovered planet circulating in that region, and Baron de Zach went so far as to calculate in 1784–5, the orbit of this ideal planet. So confident were astronomers of the existence of a planet, that in 1800, six astronomers, of whom Baron de Zach was one, assembled at Lilienthal, and formed an association of twenty-four observers, the principal object of which was to use their own language "to force this planet from the regions of analogy into the realms of sense;" but before they had got fully organized, Piazza discovered Ceres; after another year Olbers discovered Pallas, and Juno and Vesta were brought in at intervals of a few years. The search continued fruitless for ten years, it was fairly concluded that this region was exhausted. In consequence of the discovery of four small planets instead of one large planet, the new and somewhat novel idea was advanced by Dr. Olbers, that these bodies were originally united in one planet; but by some internal explosion had been blown in pieces.

This theory has been fully discussed by astronomers from that time to the present day. Several support the theory of Olbers, while others discard it entirely as untenable. In 1845, astronomers turned their telescopes again to this field for exploration, and they have succeeded in discovering *nineteen* new *asteroids* which makes the whole number *twenty-three.* The first four, Ceres, Pallas, Juno and Vesta are from the sixth to the eighth magnitude; while the nineteen new ones are less than the ninth in magnitude; all of these bodies are very small and are rough with sharp angular points; these facts would seem to indicate that they had formerly been united in one body.

The following is a list of the names, date of discovery, and by whom discovered.

| Name and Number. | Date of Discovery. | Name of Discoverer. |
|---|---|---|
| 1. Ceres | 1800, Jan. 1. | Piazza, of Sicily. |
| 2. Pallas | 1802, Mar. 28. | Olbers, of Bremen. |
| 3. Juno | 1804, Sept. 1. | Harding. |
| 4. Vesta | 1807, Mar. 29. | Olbers. |
| 5. Astrea | 1845, Dec. 8. | Hencke, of Germany. |
| 6. Hebe | 1847, July 1. | Hencke. |
| 7. Iris | 1847, Aug. 13. | Hind, of London. |
| 8. Flora | 1847, Oct. 18. | Hind. |
| 9. Metis | 1848, April 26. | Graham, of Ireland. |
| 10. Hygeia | 1849, April 12. | De Gasparis, of Naples. |
| 11. Parthenope | 1850, May 11. | De Gasparis. |
| 12. Victoria | 1850, Sep. 13. | Hind. |
| 13. Egeria | 1850, Nov. 2. | De Gasparis. |
| 14. Irene | 1851, May 19. | Hind. |
| 15. Eunomia | 1851, July 29. | De Gasparis. |
| 16. Psyche | 1852, Mar. 17. | De Gasparis. |
| 17. Thetis | 1852, April 17. | Luther, of Germany. |
| 18. Melpomene | 1852, June 24. | Hind. |
| 19. Fortuna | 1852, Aug. 22. | Hind. |
| 20. Massilia | 1852, Sept. 19. | De Gasparis. |
| 21. Lutetia | 1852, Nov. 15. | Goldschmidt, of Germany. |
| 22. Calliope | 1852, Nov. 16. | Hind. |
| 23. Thalia | 1852, Dec. 15. | Hind. |

# JUPITER.




1280 TIMES LARGER THAN THE EARTH.

## TELESCOPIC VIEWS OF JUPITER

FIG.1&2

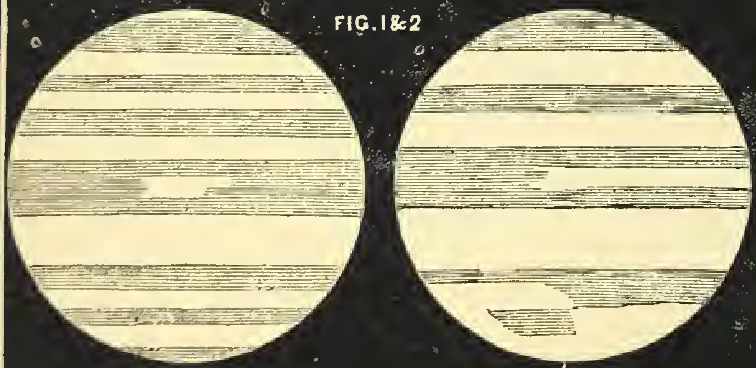
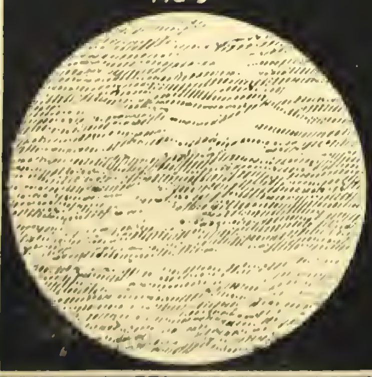


FIG 3



JUPITER

## TELESCOPIC VIEWS OF MARS

MARS

# LESSON XXVIII.

## JUPITER.

*Question.* WHAT is Jupiter?

*Answer.* Jupiter is the largest planet in the solar system.

*Q.* How many times larger is Jupiter than the earth?

*A.* It is 1,280 times greater.

*Q.* What is the specific gravity of Jupiter?

*A.* It is about $1\frac{1}{3}$ times the weight of water. (1.30.)

*Q.* How far is Jupiter from the sun?

*A.* 485 millions of miles.

*Q.* What is its diameter?

*A.* 87,000 miles.

*Q.* Which diameter is the greater, the polar or equatorial?

*A.* The equatorial diameter is 6,000 miles greater than the polar.

*Q.* What causes the equatorial diameter, so much to exceed the polar?

*A.* The quick rotation of the planet upon its axis.

*Q.* In what time does it revolve upon its axis?

*A.* In about 10 hours. (9h. 55m. 50s.)

*Q.* In what time does it revolve around the sun?

*A.* In eleven years, 314 days.

*Q.* How fast does it move in its orbit around the sun?

*A.* 30,000 miles an hour.

*Q.* How many moons has Jupiter?

*A.* Four.

*Q.* What is their magnitude?

*A.* They are about the size of our Moon.

*Q.* Who first discovered them?

*A.* Galileo, the inventor of the telescope in 1610.

*Q.* How are the orbits of these Moons situated?

*A.* They are directly over his equator.

*Q.* Do these moons frequently eclipse the Sun?

*A.* They do at each revolution around the Sun.

*Q.* What great discovery was made by observing these eclipses?

*A.* The velocity of Light. (Note.)

*Q.* Has Jupiter any change of seasons?

*A.* It has no change of seasons.

*Q.* Why do its seasons not change?

*A.* Because its axis is nearly perpendicular to the plane of its orbit, which causes the sun to be always vertical at the equator. (See Diagram.)

*Q.* How does Jupiter appear, when viewed with a telescope?

*A.* Light and dark belts appear to surround it. (See Fig. 1 and 2.)

*Q.* What are the light belts?

*A.* They are supposed to be clouds, which are thrown into parallel lines by the quick rotation of the planet upon its axis.

*Q.* What are the dark belts?

*A.* They are probably the body of the planet, seen between the clouds.

*Q.* Do these belts always appear the same?

*A.* They change frequently, and sometimes the clouds break to pieces. (See Fig. 3.)

*Q.* What is the velocity of its equatorial parts, in turning on its axis?

*A.* 25,000 miles an hour.

*Q.* What amount of light and heat has Jupiter?

*A.* It has 27 times less than the earth.

## SATURN'S RINGS.

(*From the American Almanac and Repository of useful Knowledge*, 1852).

WITHIN a few months the inquiry has been started with fresh interest, By how many rings is Saturn surrounded, and in what way are these rings sustained? Short saw two or three divisions outside of the centre of breadth. Herschel the first, in 1780, saw a new division near the inner edge. As this appearance was temporary, he thought that observation would not justify the supposition of multiple rings. Lines of demarcation were seen on both rings in 1813 and 1814. Quetelet saw the outer ring divided in 1823 In 1825 and 1826 three divisions were seen on the outer ring by Kater. In 1837 Encke noticed that the outer ring was divided, and that there were several marks near the inner edge of the inner ring. De Vico has given an account of several divisions seen by him on both rings. In 1838 several divisions were seen at Rome, which are described by Decuppis. In 1843, Lassell and Dawes saw a division of the outer ring. Smyth gives an account of the last case, and adds: "After such unquestionable evidence, there can be no reasonable doubt of the outer ring's being multiple." On the 11th of November, 1850, G. P. Bond saw what he thought at the time a second division of the ring, near the inner edge of the inner ring. On the 15th, his father thought the new ring was wholly disconnected with the old, though the edge next to the planet was better defined than the outer edge. Micrometric observations gave for the inner diameter of the inner division 26".3, whereas, according to Encke, the inner diameter of the old inner ring should be at that time 29"8. From this it was inferred that the large refractor at Cambridge had revealed an entirely unknown and darker ring of Saturn, which was not to be confounded with the division of the old inner ring which had frequently been noticed. The outer edge of the new ring is 1".5 within the inner edge of any ring hitherto visible. This conclusion was confirmed by observations continued for several weeks. Similar appearances were noticed on the 25th and 26th of November, by Mr. Dawes, and afterwards by Lassell of Liverpool, and Schmidt of Bonn.

On the 15th of April, 1851, G P. Bond communicated to the American Academy of Arts and Sciences at Boston, a memoir on the rings of Saturn. After rehearsing the facts already detailed in regard to extraordinary divisions of the rings, he draws attention to the circumstance that other observers, as Struve, Bessel, J, F. W. Herschel, and, we may add, Smyth, have seen only the usual division, even with the best instruments, and under the most favorable circumstances. Moreover, the divisions on both rings are not always seen simultaneously; and the Cambridge telescope which has brought to view a ring always before invisible, does not indicate any of the unusual divisions in the two old rings. It seems a justifiable conclusion from all the facts, that the multiplicity of rings occasionally seen, and the failure to discern more than two at other times, are not referrable to the difference of instruments, to the greater or less purity of the air, or to the unequal skill of observers, but to a material fluctuation in the ring itself.

In a lecture publicly delivered in Reading, Pennsylvania, on the 3d of January, 1851, Mr. Kirkwood made the following remarks:—"This gives rise to the interesting question whether the rings of Saturn may not be the most recent cosmical formation within the limits of the solar system, and whether it may not, in the course of future ages, collect about a nucleus and constitute a satellite. The evidence of its solidity is not, I think, by any means conclusive. On the other hand, observations made within the last few years give a degree of plausibility to the presumption that it may be in a state of fluidity. I refer to the occasional appearance of dark lines, chiefly on the outer rings, which have been supposed to indicate a subdivision into several concentric annuli. They do not, however, appear to be permanent; at least they are subject to some change, as they are not always visible even when circumstances would seem most favorable.

Such are the considerations which led Mr. Bond to reject the idea of solid rings, and to suppose these appendages of Saturn to be fluid or semi-fluid. If this is the material, it is unnecessary to suppose that the inner and outer surfaces move round in the same time. The velocity at every point may be such, that the centrifugal and other forces balance each other. "And even should an accumulation of disturbances, of which the absence of inequalities lessens the probability, bring the rings together, the velocities at the point of contact will be very nearly equal, and the two will coalesce without disastrous consequences." "If, in its normal condition, the ring has but one division, as is commonly seen, under peculiar circumstances it might be anticipated that the preservation of their equilibrium would require a separation in some regions of either the inner or outer ring; this would explain the fact of occasional subdivisions being seen. There being visible but for a short time, and then disappearing to the most powerful telescopes, is accounted for by the removal of the sources of disturbance, when the parts thrown off would reunite"

"Finally, a fluid ring, symmetrical in its dimensions, is not of necessity in a state of unstable equilibrium, with reference either to Saturn or the other rings."

At the meeting at Cincinnati of the American Association for the Advancement of Science, Professor B. Peirce, read a memoir on the constitution of Saturn's ring, containing the same general views which he submitted to the American Academy of Arts and Sciences at Boston, on the 15th of April, 1851. Mr. Peirce arrives at the same results by analysis as those which Mr. Bond had derived from observations, illustrated and combined by his own ingenious computations. Mr Peirce differs in opinion from Laplace, in regard to the efficacy of an irregular figure in sustaining Saturn's ring. He considers this statement of Laplace, which his successors have blindly adopted, as a careless suggestion, and not the ripened fruit of his usual rigid examination. "I maintain," he says, "unconditionally, that *there is no conceivable form of irregularity, consistent with an actual ring, which would serve to retain it permanently about the primary, if it were solid.*"

The stability of the ring does not depend on the attraction exerted on it by the planet. In the circulation of the fluid annulus around Saturn, the velocity is least at the greatest distance. Hence the matter accumulates at the most remote point of the ring, and to such an extent that the quantity of matter balances the distance, and the attraction exerted by the ring and the planet on each other is the same in every direction. The ring is held together by the attraction of the primary; but it is not sustained as a whole by the primary. It is sustained by the satellites. The satellites disturb it, and sustain it by a delicate equipoise of disturbances. Something like this restorative action had been hinted at by Sir J. F. W Herschel. But the remedial power is insufficient to sustain a solid ring. It follows that no planet can have a ring unless richly provided with menials to hold it. Saturn alone of all the planets seems competent to preserve a ring when once bestowed.

Mr. Peirce concludes his memoir with the following weighty paragraph: "Were the ring, however, supposed to be a large gaseous mass of a circular figure, the condensation which would occur at the point of aphelion might easily lead to chemical action. Precipitation might ensue, and the necessary consequence would seem to be a continually accelerated accumulation at this point, which would terminate in the formation of a planet. Under this modification, the nebular hypothesis may possibly be free from some of the objections with which it has been justly assailed. But in approaching the forbidden limits of human knowledge, it is becoming to tread with caution and circumspection. Man's speculations should be subdued from all rashness and extravagance in the immediate presence of the Creator.

[The rings of Saturn have been considered by the most celebrated astronomers, Laplace, Struve, Bessel, Sir William Herschel, J. F. W. Herschel, Smyth and others, as being solid bodies surrounding the planet and of the same materials and density; but Mr. G. P. Bond of Cambridge, and Professor Pierce, have advanced a new theory in regard to these rings, that they are a fluid or semi-Liquid matter. In regard to this novel Theory it is not considered by astronomers ss fully established. We have not adopted this new theory in this work, preferring to wait for a further demonstration of it. We are however inclined to believe that the various phenomena are more easily explained upon this hypothesis.—AUTHOR.

## NOTE.

In 1675 it was observed by Roemer a Danish Astronomer, that when the earth was nearest to Jupiter the eclipses of his sattellites took place 8 minutes 13 seconds *sooner* than the time specified in the astronomical tables; but when the earth was farthest from Jupiter, the eclipses took place 8 minutes 13 seconds too late, the difference being 16m. 26s. From this it appears that it takes light 16m. 26s. to pass across the earth's orbit which is 190 millons of miles in diameter—190 millions of miles divided by 986 the number of seconds in 16m. 26s. gives 192,697 miles as the velocity of light per second.


SATURN
N
AT THIS POINT THE SUN SHINES ONLY UPON THE EDGE OF THE RING
IN THIS HALF OF THE ORBIT THE SUN SHINES ONLY UPON THE SOUTH SIDE OF THE RINGS DURING 15 YEARS NEARLY
IN THIS HALF OF THE ORBIT THE SUN SHINES ONLY UPON THE NORTH SIDE OF THE RINGS DURING 15 YEARS NEARLY
THE SUN SHINES ONLY UPON THE EDGE OF THE RING
PERPENDICULAR VIEW OF SATURN'S RINGS
SATURN
A VIEW OF SATURNS RINGS AND MOONS AS SEEN FROM THE PLANET AT MIDNIGHT
THE DARK SHADE IS THE SHADOW OF THE PLANET UPON THE RINGS:

## LESSON XXIX.

### SATURN.

*Question.* What is Saturn ?
*Answer.* It is the largest planet except Jupiter.

*Q.* What is its magnitude compared with the earth ?
*A.* It is about 1,000 times larger.

*Q.* What is its specific gravity ?
*A.* It is about one half the weight of water. (0.56.)

*Q.* What is the diameter of Saturn ?
*A.* 79,000 miles.

*Q.* What is its distance from the sun ?
*A.* 890 millions of miles.

*Q.* In what time does it revolve on its axis ?
*A.* In about $10\frac{1}{2}$ hours. (10h. 29m. 16s.)

*Q.* In what time does it revolve around the sun ?
*A.* In 29 years and a half. (29y. 167d.)

*Q.* How fast does it move in its orbit around the sun ?
*A.* 22,000 miles an hour.

*Q.* Is there any change of seasons at Saturn ?
*A.* There is, but it is very slow, as it takes nearly thirty of our years, to complete a year at Saturn.

Q. How much does the axis of Saturn lean towards its orbit ?
*A.* About 30 degrees. (28° 40′.) (See Diagram.)

*Q.* How long is it day and night alternately at the poles ?
*A.* About 15 of our years. (See Diagram.)

*Q.* What has Saturn which surrounds it ?
*A.* Two large rings of solid matter like the planet. (See Diagram.)

*Q.* What is their position around the planet ?
*A.* They are directly over the equator.

## LESSON XXX.

*Q.* Do these rings revolve with the planet !
*A.* They do, and in nearly the same time as the planet.

*Q.* Are these rings connected with the planet or separate ?
*A.* They are separate from the planet and from each other.

*Q.* What is the distance from the planet to the inner ring ?
*A.* 19,000 miles.

*Q.* How wide is the inner ring ?
*A.* 17,000 miles.

*Q.*. How wide is the space between the rings ?
*A.* About 1,800 miles.

*Q.* What is the width of the outer ring ?
*A.* 10,000 miles.

*Q.* How thick are these rings ?
*A.* About 100 miles. (Some say 1,000 miles.)

*Q.* Are these rings uniform ?
*A.* They are rough and uneven.

*Q.* How many satellites or moons has Saturn ?
*A.* Eight.

*Q.* What is the position of their orbits ?
*A.* Their orbits, excepting one, are directly over the rings. (See Diagram.)

*Q.* Does the sun always shine on the same side of the rings ?
*A.* It shines upon each side alternately for fifteen years. (See Diagram.)

*Q.* What amount of light and heat has Saturn ?
*A.* It has 90 times less than the earth.

*Q.* What appearance has the disc of Saturn !
*A.* It has dark belts similar to those of Jupiter.

### Saturn.

According to heathen mythology, Saturn was the deity who presided over time. He is sometimes represented as an old man, flying with wings attached to his back ; carrying an hour-glass in one hand, and a scythe in the other. These are very appropriate emblems of time ; the old man represents time, his flying admonishes us to improve every moment as it comes, or it will be lost ; the hour-glass reminds us that our life, like the sand in the glass, will soon run out ; and the scythe, like time,

"Cuts down all,
Both great and small."

Saturn is the 6th lunar planet from the sun, and the most remarkable ; it is next in order to Jupiter, and the most remote planet from the earth, of any that are visible to the naked eye. It may easily be distinguished from the fixed stars by its pale, feeble and steady light. It is 890 millions of miles from the sun, and revolves around it in 29 years 167 days ; so that its apparent motion among the stars is very slow, being only 12 degrees in a year. Saturn, besides being attended with seven moons, is surrounded by two large concentric rings, which are separate from each other, and also from the planet. The matter, of which these rings are composed, is undoubtedly no less solid than the planet, and they are observed to cast a strong shadow upon the planet itself. Saturn, in bulk, is about 1,000 times larger than the earth, and revolves on its axis in 10h. 29m. 16s. This rapid motion upon its axis, causes it to be, like Jupiter, very much flattened at the poles. So that the equatorial diameter is to the polar, as 12 to 11. The rings of Saturn present a phenomenon, to which there is nothing analagous in the rest of the solar system. These rings are very thin, one within the other, and directly over the equator. They revolve round in the same time with the planet, although they are detached from it.

The axis of Saturn is inclined to that of it's orbit 28° 40′, and as the rings are in the plane of the equator, the axis of the rings has the same inclination. It will be seen from this, (see Diagram,) that the sun shines alternately for 15 years on one side of the rings, and then upon the other ; so that if we lived upon the rings, we should have continued day for 15 years, and then continual night for the same length of time.

The rings of Saturn must present to the inhabitants of the planet a most magnificent spectacle. They appear like vast arches, or semicircles of light, extending from the eastern to the western horizon. At the equator, the outer ring is not visible, being hidden from the view by the inner ring ; but, in about 45 degrees of latitude, both rings are visible, and present a magnificent appearance. During the day-time, they appear dim like a white cloud, but, as the sun goes down their brightness increases ; while the shadow of the planet is seen to come on at the eastern limb of the ring, and gradually rise to the zenith, (see Diagram,) when it passes down and disappears in the western horizon at the rising of the sun. The rays of the sun always fall upon the sides of the rings very obliquely, as the sun is never seen more than 30 degrees above the horizon of the rings, while at other times the edge of the rings only is presented to the sun. (See Diagram.) These rings are rough and of unequal width and thickness, and it has been demonstrated that these rings could not maintain their stability of rotation, if they were in all parts of equal thickness and density, as the smallest disturbance would destroy their equilibrium, which would continue to increase until at last, they would be precipitated upon the planet.

Saturn has seven moons, or satellites, but they are only seen with a good telescope. Their orbits, with the exception of the seventh, are nearly in the plane of the rings ; the seventh, which is the farthest from the planet, is the largest, and its orbit is considerably inclined to the plane of the rings. (See Diagram.)


HERSCHEL OR URANUS, & LEVERRIER OR NEPTUNE.
LEVERRIER
HERSCHEL WITH 6 MOONS
EARTH.

## LESSON XXXI.

### HERSCHEL, OR URANUS.

*Question.* When was Herschel or Uranus discovered?

*Answer.* In 1781.

*Q.* By whom?

*A.* By Sir William Herschel, who was a celebrated English astronomer.

*Q.* In what part of the solar system is Herschel situated?

*A.* It is the 7th large planet from the sun, and next to the farthest discovered.

*Q.* What is its magnitude?

*A.* It is 80 times larger than the earth.

*Q.* What is its specific gravity?

*A.* It is $1\frac{1}{2}$ times the weight of water. (1.53.)

*Q.* What is its distance from the sun?

*A.* 1800 millions of miles.

*Q.* In what time does it revolve on its axis?

*A.* It is not certainly known. [It has been stated at 1 day 18 hours, but there seems to be no proof of it.] *Professor Nichol.*

*Q.* In what time does it revolve around the sun?

*A.* In about 84 years. (84*y.* 6*d.*)

*Q.* How fast does it move in its orbit around the sun?

*A.* 15,000 miles an hour.

*Q.* How will the light and heat at Herschel, compare with the same at the earth?

*A.* They are 368 times less.

*Q.* How many moons has Herschel?

*A.* Six moons were seen by Sir Wm. Herschel, but only three have been seen by other astronomers.

*Q.* What angle do the orbits, of the two which are best known, make with the ecliptic?

*A.* An angle of 78 degrees. (78° 58′.)

*Q.* In what direction do these moons move in their orbits?

*A.* They move from east to west, contrary to the motions of all the other planets, both primary and secondary.

## LESSON XXXII.

### LEVERRIER, OR NEPTUNE.

*Q.* When was Neptune discovered?

*A.* In 1846, by Dr. Galle, of Berlin.

*Q.* Who published the elements of this planet, and directed astronomers to the point in the heavens where it might be discovered?

*A.* Leverrier, a celebrated French mathematician.

*Q.* How near the point, where he directed astronomers to look, was it found?

*A.* Within one degree.

*Q.* What is the diameter of this planet?

*A.* It is about 35,000 miles.

*Q.* What is its magnitude?

*A.* It is about 80 times larger than the earth.

*Q.* What is its distance from the sun?

*A.* About 2,850 millions of miles.

*Q.* In what time does it revolve on its axis?

*A.* It is not known.

### LEVERRIER, OR NEPTUNE.—Continued.

*Q.* In what time does it revolve around the sun?

*A.* In about 166 years.

*Q.* How many moons has Leverrier?

*A.* One; and another is supposed to have been seen.

*Q.* What amount of light and heat has this planet?

*A.* About 900 times less than that of the earth.

*Q.* Does this planet correspond to the calculations of Leverrier, as to mass and distance from the sun?

*A.* Its mass and distance are considerably less than his calculations.

*Q.* What have these circumstances led some astronomers to suppose?

*A.* That Leverrier is one of a group of planets similar to the Asteroids, situated at nearly the same distance from the sun.

*Q.* Are the primary planets inhabited?

*A.* They appear to be inhabitable.

[Note.—The presence of clouds indicating both air and water; the regular succession of the seasons, as well as day and night; the suitable amount of light received from the sun; the accompaniment of moons; the specific gravity of bodies at their surface; all seem to indicate that the primary planets are suitable residences for living beings. The only objection to this view is, the difference in the amount of heat received from the sun, supposing it to be according to the inverse ratio of the squares of their distances from the sun. But we see from the difference of temperature on the earth, at the base and summit of high mountains, that the actual heat depends much upon the modifying circumstances, as well as upon the direct rays of the sun. And we have reason to suppose that the temperature of the other planets does not differ much from that of the earth.

For instance, the temperature of Mars, as indicated by the melting of its snow, and that of Jupiter and Saturn, as indicated by the amount of vapor in their atmosphere, appear to be similar to that of the earth. Mercury and Venus are protected from the direct rays of the sun by dense clouds. Causes unknown to us, may and probably do, modify the temperature of all the planets in a greater or less degree, sufficiently so, for the purposes of animal life.]

### HERSCHEL.

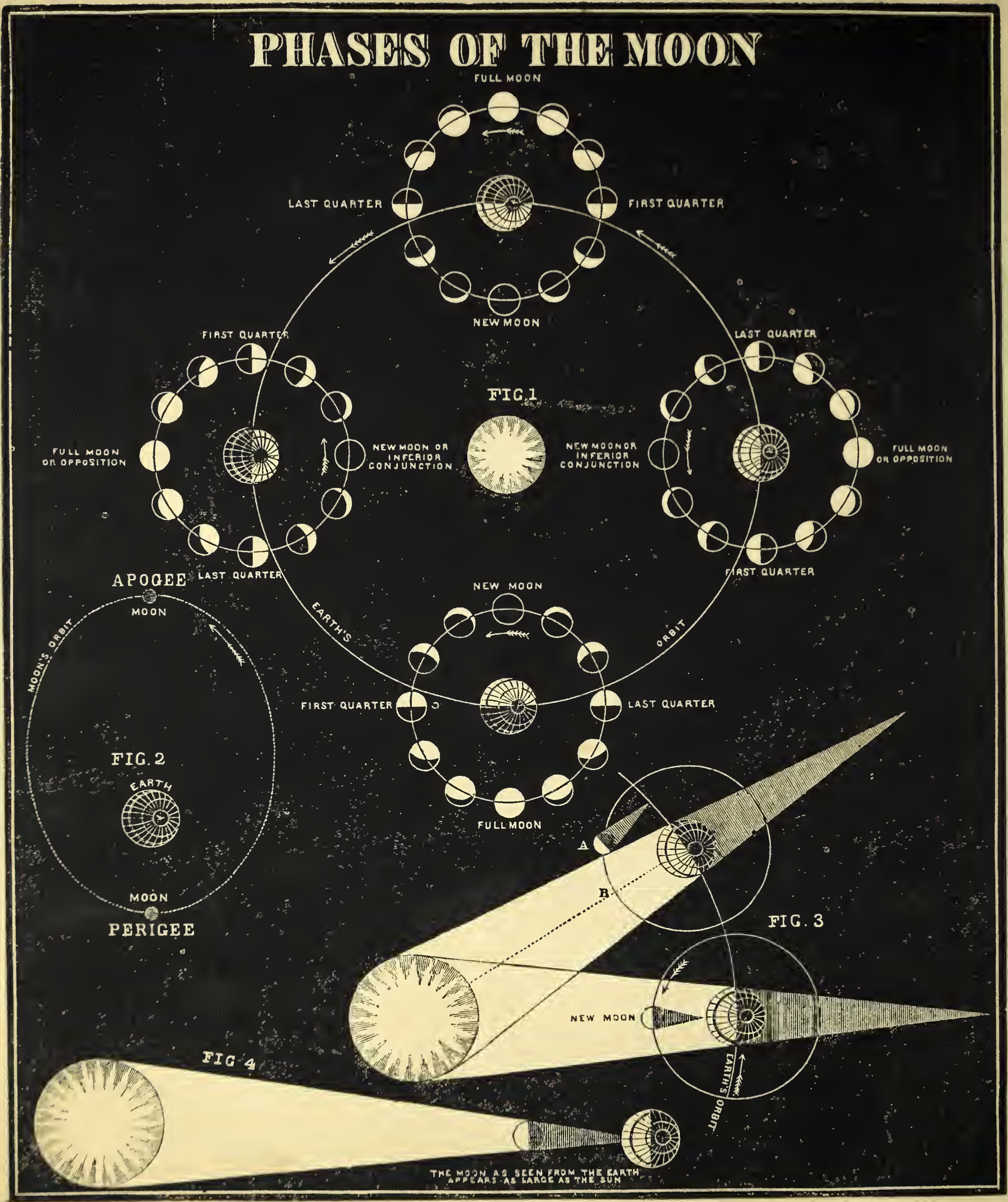
This planet was discovered by Sir William Herschel, March 13th, 1781. It had been observed by Flamstead, Mayer, Tycho Brahe, and other astronomers, and was regarded by them as a fixed star, and such it was considered by Dr. Herschel, until he discovered it to be a planet, from its having moved from the place where he had observed it some time before.

Sir William Herschel gave it the name of "*Georgium Sidus*, or Georgian Star," in honour of his Royal patron, George III., but the Royal Academy of Prussia, called it Uranus.

### THE NEW PLANET.

CAUSE WHICH LED TO ITS DISCOVERY.

It had been found by observation, that the attraction of the planets upon each other, accelerate or retard the motion of each. These variations have been well understood by astronomers for many years; but it was found by a series of observations made during several years upon the planet Herschel, that its motion in the heavens was affected by some cause other than that of Saturn or Jupiter. This led astronomers to suspect that there might be another planet, either between the orbits of Saturn and Herschel, or beyond that of Herschel. *Leverrier*, having collected the observations of the most celebrated astronomers for many years, was enabled, by his profound knowledge of the mathematics, to calculate its elements.


PHASES OF THE MOON
FULL MOON
LAST QUARTER
FIRST QUARTER
NEW MOON
FIRST QUARTER
LAST QUARTER
FIG.1
FULL MOON OR OPPOSITION
NEW MOON OR INFERIOR CONJUNCTION
NEW MOON OR INFERIOR CONJUNCTION
FULL MOON OR OPPOSITION
LAST QUARTER
FIRST QUARTER
APOGEE
MOON
MOON'S ORBIT
NEW MOON
EARTH'S
ORBIT
FIRST QUARTER
LAST QUARTER
FIG. 2
EARTH
FULL MOON
A
B
MOON
PERIGEE
FIG. 3
NEW MOON
EARTH'S ORBIT
FIG 4
THE MOON AS SEEN FROM THE EARTH APPEARS AS LARGE AS THE SUN

## LESSON XXXIII.

### MOON.

*Question.* What is the moon?

*Answer.* The moon is a secondary planet, revolving around the earth.

*Q.* Is the moon larger or smaller than the earth?

*A.* It is 49 times less than the earth.

*Q.* What is the diameter of the moon?

*A.* 2,180 miles.

*Q.* What is the specific gravity of the moon?

*A.* It is 3½ times the weight of water, (3.37.)

*Q.* What is its mean distance from the earth?

*A.* Two hundred and forty thousand miles.

*Q.* In what time does the moon revolve around the earth?

*A.* In about 27½ days, (27*d.* 7*h.* 43*m.* 11*s*.5.)

*Q.* In what time does the moon revolve upon its axis?

*A.* In about 27½ days, or in the same time that it revolves around the earth.

*Q.* What is the result of the moon's revolving upon its axis and around the earth in the same time?

*A.* The same side of the moon is always presented to the earth.

*Q.* Have we ever seen the opposite side of the moon?

*A.* We have not.

*Q.* What causes the moon always to present the same side to the earth?

*A.* It is supposed that one side of the moon is more dense than the other, consequently the centre of gravity is not in the centre of the moon.

*Q.* What is a lunation, or lunar month?

*A.* It is the time from one new moon to another.

*Q.* What is the length of a lunation?

*A.* About 29½ days. (29*d.* 12*h.* 44*m.*)

*Q.* Why is a lunation longer than the time it takes the moon to revolve around the earth?

*A.* Because the earth is revolving around the sun at the same time. (Fig. 3. See Note 1.)

## LESSON XXXIV.

*Q.* What is the length of the days or nights at the moon?

*A.* About 15 of our days. (Note 4.)

*Q.* Which way does the moon revolve around the earth?

*A.* From west to east.

*Q.* If the moon revolves from west to east, what causes it to rise in the east?

*A.* It is caused by the earth's revolving on its axis the same way. (Note 2.)

*Q.* Does the moon rise the same hour every evening?

*A.* It rises about 50 minutes later every day.

*Q.* What is the cause of its rising 50 minutes later every day?

*A.* It is caused by the moon's revolving around the earth from west to east.

*Q.* What causes the phases of the moon, from new moon to new moon again?

*A.* It is caused by the moon's revolving around the earth. (See Diagram. Note 3.)

*Q.* When is it new moon?

*A.* When the moon is between the earth and sun, and the dark side is presented to us. (Fig. 1.)

### MOON.—Continued.

*Q.* When is it full moon?

*A.* When the moon is upon the opposite side of the earth from the sun, and the illuminated side is presented to us. (Fig. 1.)

*Q.* How much greater is the light of the sun than the full moon?

*A.* 300,000 times greater.

*Q.* When are the sun and moon in quadrature?

*A.* When they are ninety degrees distant from each other. (Fig. 1.)

*Q.* How much of the illuminated side of the moon is visible to us when it is in quadrature?

*A.* One-half. (Fig. 1.)

*Q.* How much larger is the sun than the moon?

*A.* 70 millions of times greater.

*Q.* Why does the moon appear as large as the sun?

*A.* Because it is four hundred times nearer to us than the sun. (See Fig. 4.)

---

*Note* 1. *Fig.* 3.—The moon revolves around the earth in about 27½ days, but from one new moon to another it is about 29½ days; this difference is caused by the earth's revolving around the sun at the same time that the moon is revolving around the earth. This will appear plain by examining Fig. 3, on the opposite page. If we suppose the moon to be in conjunction or new moon, while the moon is revolving around the earth, the earth moves through nearly one-twelfth part of its orbit, and when the moon arrives at A, it will have made a complete revolution around the earth; but the moon will not be in conjunction, or between the earth and sun, until it has moved the distance from A to B—hence it will be seen that from one new moon to another the moon has to make more than one complete revolution around the earth.

*Note* 2.—That the moon revolves around the earth from west to east, from one new moon to another in about 29½ days, there is not the least doubt; and it will appear perfectly plain if we consider that the earth is revolving on its axis the same way, or from west to east; the earth revolves on its axis in 24 hours, whereas the moon is 29½ days in revolving around the earth; consequently the moon only moves from west to east in 24 hours, as much as the earth turns on its axis in 50 minutes, which makes the moon rise as much later every evening. If the earth did not revolve upon its axis, then the moon would rise in the west, and after being above the horizon for nearly 15 days, would set in the east, and would be below the horizon for the same length of time, when it would rise again in the west.

#### PHASES OF THE MOON.

*Note* 3. *Fig.* 1.—By phases of the moon is meant the various appearances which the moon presents from new to full moon, and from full moon to new moon again. As the moon is a dark body of itself, there is only one-half of its surface illuminated by the sun. At new moon, when the moon is between the earth and sun; that side of the moon upon which the sun shines, is towards the sun, and the dark side is presented to the earth; consequently we do not see any portion of the illuminated side of the moon at new moon, *see Fig.* 1; but as the moon passes around from west to east, it brings the illuminated side of the moon more and more to our view; at the first quarter we can see one-half of the illuminated surface, and when the moon arrives at full moon, we can see the whole of the illuminated surface, as the earth is then between the sun and moon. From full moon to new moon again, the illuminated surface disappears in the same manner as it appeared.

#### LENGTH OF THE DAYS AND NIGHTS AT THE MOON.

*Note* 4. As the moon revolves on its axis only once in its revolution around the earth, it continually presents the same side to the earth, and there would be, consequently, only one day and night in each revolution of the moon around the earth, or the day and night would each be nearly fifteen days long.


TELESCOPIC VIEW OF THE NEW MOON
NORTH
EAST
WEST
SOUTH

## LESSON XXXV.

### MOON.—Continued.

*Question.* Has the moon an atmosphere?

*Answer.* Very little if any.

*Q.* What is the appearance of the moon when viewed with a telescope?

*A.* It appears covered with light and dark spots of various shapes.

*Q.* What is the cause of this appearance?

*A.* It is caused by the mountains, plains and valleys in the moon.

*Q.* What are the light spots?

*A.* Mountains and elevated land.

*Q.* What are the dark spots?

*A.* Plains, valleys, &c.

*Q.* Has the moon any oceans, seas, or large bodies of water?

*A.* Not upon the side towards the earth.

*Q.* If you were living upon this side of the moon, what would be the appearance of the earth?

*A.* The earth would appear like a large stationary moon.

*Q.* How much larger than the moon appears to us?

*A.* Thirteen times greater.

*Q.* In what time would the heavenly bodies appear to revolve around the moon?

*A.* The stars would appear to revolve in 27½ days, the sun in 29½ days.

*Q.* What is the shape of the moon's orbit?

*A.* Elliptical, or one diameter greater than the other. (*See Diagram*, page 24.)

*Q.* What is apogee?

*A.* It is the point in the orbit of the moon farthest from the earth.

*Q.* What is perigee?

*A.* It is the point in the orbit of the moon nearest to the earth.

*Q.* When is the moon in apogee?

*A.* When it is at its greatest distance from the earth.

*Q.* When is the moon in perigee?

*A.* When it is nearest to the earth.

*Q.* Has the moon any change of seasons?

*A.* None, except those changes which take place every lunar month.

*Q.* What is the harvest moon?

*A.* When the moon is full in September and October, it rises only a few minutes later for several successive evenings, and thus affords light for collecting the harvest, it is therefore called the harvest moon.

*Q.* What is the cause of the harvest moon?

*A.* It is caused by the moon's orbit being very oblique to the horizon.

*Q.* Is the moon inhabited?

*A.* The want of air and water, render it uninhabitable by beings like ourselves.

## PHYSICAL CONSTITUTION OF THE MOON.

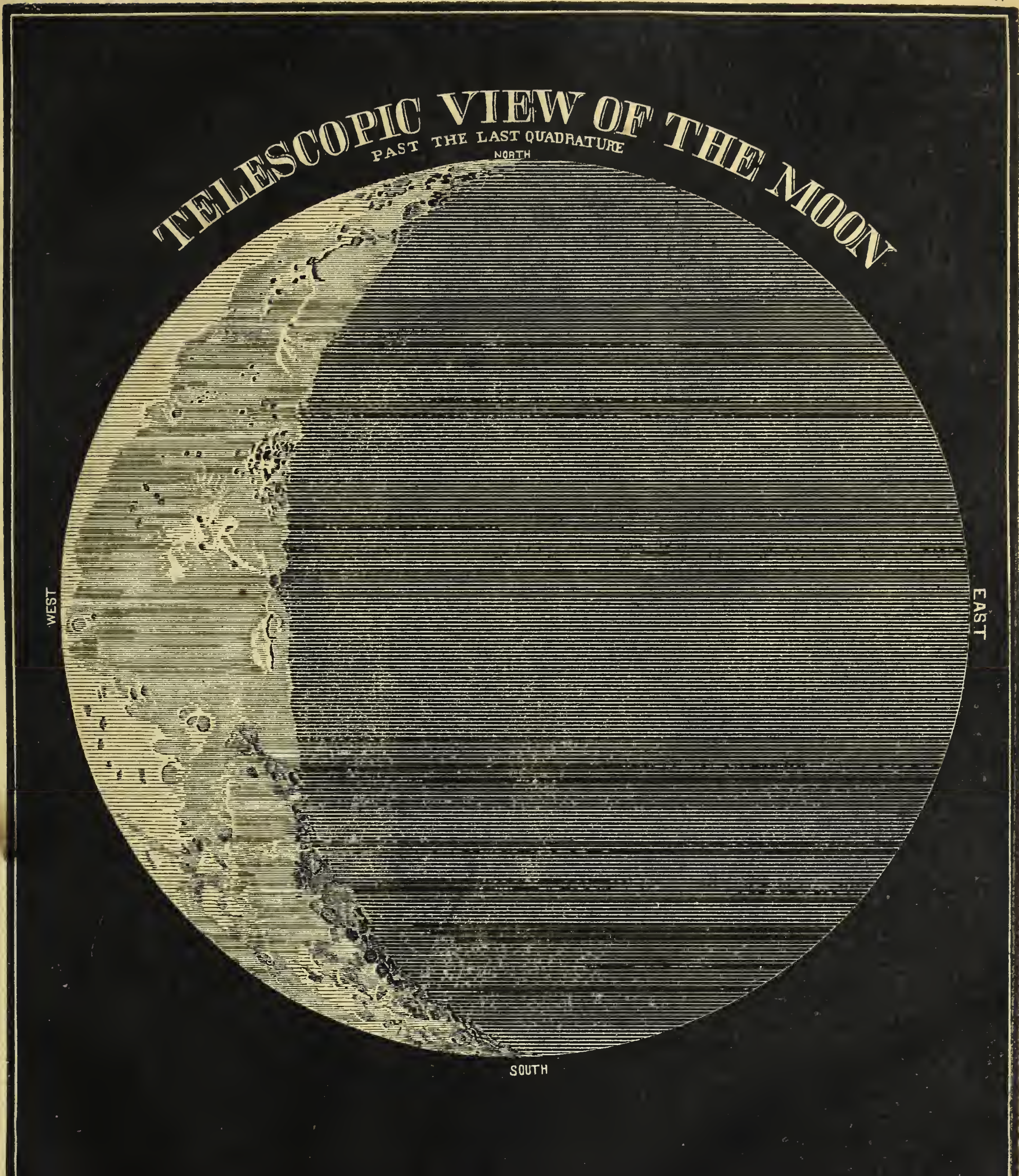
In viewing the moon with the naked eye, her disc appears diversified with dark and bright spots, which on being examined with a powerful telescope are discovered to be mountains and valleys. The whole surface of the moon is covered with these spots, which is evident from the fact that the line of separation between the illuminated and dark hemispheres, is at all times extremely ragged and uneven. The mountains on or near this line cast behind them long black shadows, like the mountains on the earth when the sun is rising or setting. The moon is a much more mountainous body than the earth, and the mountains are vastly higher compared with its size than those of the earth. One of the mountains (*named Tycho*) situated in the southeast part of the Moon, is apparently a volcanic crater 50 miles in diameter, and 16,000 feet deep, with a central mountain rising to the height of 5,000 feet. The height of ten of the principal mountains, according to the recent measurement of Mædler, is from 3½ to 4¾ miles. The mountains of the moon do not run in ranges like those of the earth; but are single peaks scattered over nearly the whole surface of the moon, and are generally of a circular form shaped like a cup. These facts substantially prove the mountains of the moon to be of volcanic origin, and in some of the principal ones, decisive marks of volcanic stratification, arising from successive deposites of ejected matter, may be distinctly traced with powerful telescopes—The moon contains no large bodies of water, such as, oceans, seas, &c., especially upon the side visible to us. If there are any, they must be upon the opposite side of the moon which is never presented to us. The moon also has very little if any atmosphere, at least, none of sufficient density to refract the rays of light in their passage through it: from these two circumstances there are no clouds floating around the moon: if there were any, they would at times be visible to us, but none have been observed, it presents the same appearance that it did 2,000 years ago; no trace of vegetation or change of seasons has been observed, every thing appears solid, desolate, and unfit for the support of animal or vegetable life. Whether the materials of which the moon is composed, are of the same nature as the earth, there are no means of knowing. From the effect of the moon's gravitation in producing the nutation of the earth's axis, the mass of the moon is determined to be very nearly 1.80th of the mass of the earth, whence, as her volume is 1.49th of the earth's volume, it follows that her density as compared with the mean density of the earth is .615 or a little more than one half; consequently the materials of which the moon is composed are about half as heavy as the same bulk of the earth.

There being little or no atmosphere about the moon, the heavens, in the daytime, have the appearance of night to the inhabitants of the moon, when they turn their backs to the sun; and the stars then appear, as bright to them as they do in the night to us; for it is entirely on account of the light which our atmosphere reflects that the heavens appear luminous about us in the daytime. If our atmosphere were removed, only that part of the heavens would be light in which the sun is situated; and if we turned our backs to the sun the heavens would appear as dark as night. The light which the full moon affords us is very small, when compared with the light of the sun; it being 300,000 times less. It has also been demonstrated that the light reflected by the moon produces no heat; as its rays, when collected by the aid of the most powerful glasses, have not been perceived to produce the slightest effect upon the thermometer.

#### IS THE MOON INHABITED?

From the physical constitution of the moon, it is evident that the moon is not inhabited; at least, by beings constituted like ourselves. The moon having no atmosphere, we could not maintain an existence upon its surface for a single hour; even if it is provided with the other necessary means for our existence: neverthless, this is not conclusive evidence that the moon is not inhabited. The same power that called the moon into existence could as easily constitute beings fitted to inhabit its surface, and enjoy an existence like that of ours. It may be very properly asked—if the moon is not a habitable body, for what purpose was it created? This is a question which is more easily asked than answered. We do know that it exerts a powerful influence in raising the tides, and how far this influence operates upon the animal and vegetable kingdoms, we are unable to decide; its influence is no doubt felt to a greater or less extent.


TELESCOPIC VIEW OF THE FULL MOON
NORTH
EAST
WEST
SOUTH


TELESCOPIC VIEW OF THE MOON
PAST THE LAST QUADRATURE
NORTH
WEST
EAST
SOUTH

## LESSON XXXVI.

### ECLIPSES.

*Question.* What is an eclipse?

*Answer.* It is the interception of the sun's rays by some opake body.

*Q.* How are eclipses divided, with respect to the body eclipsed?

*A.* Into two kinds, solar and lunar.

*Q.* What is a solar eclipse?

*A.* It is an eclipse of the sun.

*Q.* What is the cause of an eclipse of the sun?

*A.* It is caused by the moon's passing between the earth and sun, and casting its shadow upon the earth. (Fig. 3.)

*Q.* When must an eclipse of the sun take place?

*A.* It can happen only at new moon.

*Q.* What is a lunar eclipse?

*A.* It is an eclipse of the moon. (Fig. 3.)

*Q.* What causes an eclipse of the moon?

*A.* It is caused by the moon's passing through the earth's shadow. (Fig. 3.)

*Q.* When must an eclipse of the moon take place?

*A.* It can happen only at full moon. (Fig. 3 and 4.)

*Q.* How are eclipses divided, with respect to the amount eclipsed?

*A.* Into total and partial.

*Q.* What is a total eclipse?

*A.* It is an eclipse of the whole of the sun or moon. (Fig. 3 and 8.)

*Q.* What is a partial eclipse?

*A.* It is an eclipse of only a part of the sun or moon. (Fig. 7.)

*Q.* What is an annular eclipse?

*A.* It is an eclipse of the central part of the sun, when the moon is so far from the earth, that the sun can be seen like a bright ring around it. (Fig. 9, Note.)

*Q.* Do we have an eclipse of the sun at every new moon?

*A.* We do not.

*Q.* Why do we not have an eclipse of the sun at every new moon?

*A.* Because at new moon, the moon is generally too high or too low for its shadow to fall upon the earth. (Fig. 5.)

*Q.* Do we have an eclipse of the moon at every full moon?

*A.* We do not; at full moon the moon generally passes above or below the earth's shadow.

*Q.* What is the length of the earth's shadow?

*A.* About 600,000 miles. (Note. This is the mean or average length.)

*Q.* What is the length of the moon's shadow?

*A.* About 231,000 miles. (Note. This is the mean or average length.)

*Q.* What is a digit?

*A.* It is the twelfth part of the apparent diameter of the sun or moon's disc. (Fig. 6.)

*Q.* What is the greatest number of eclipses that can take place in a year?

*A.* Seven; five of the sun and two of the moon.

*Q.* What is the least number of eclipses that can take place in a year?

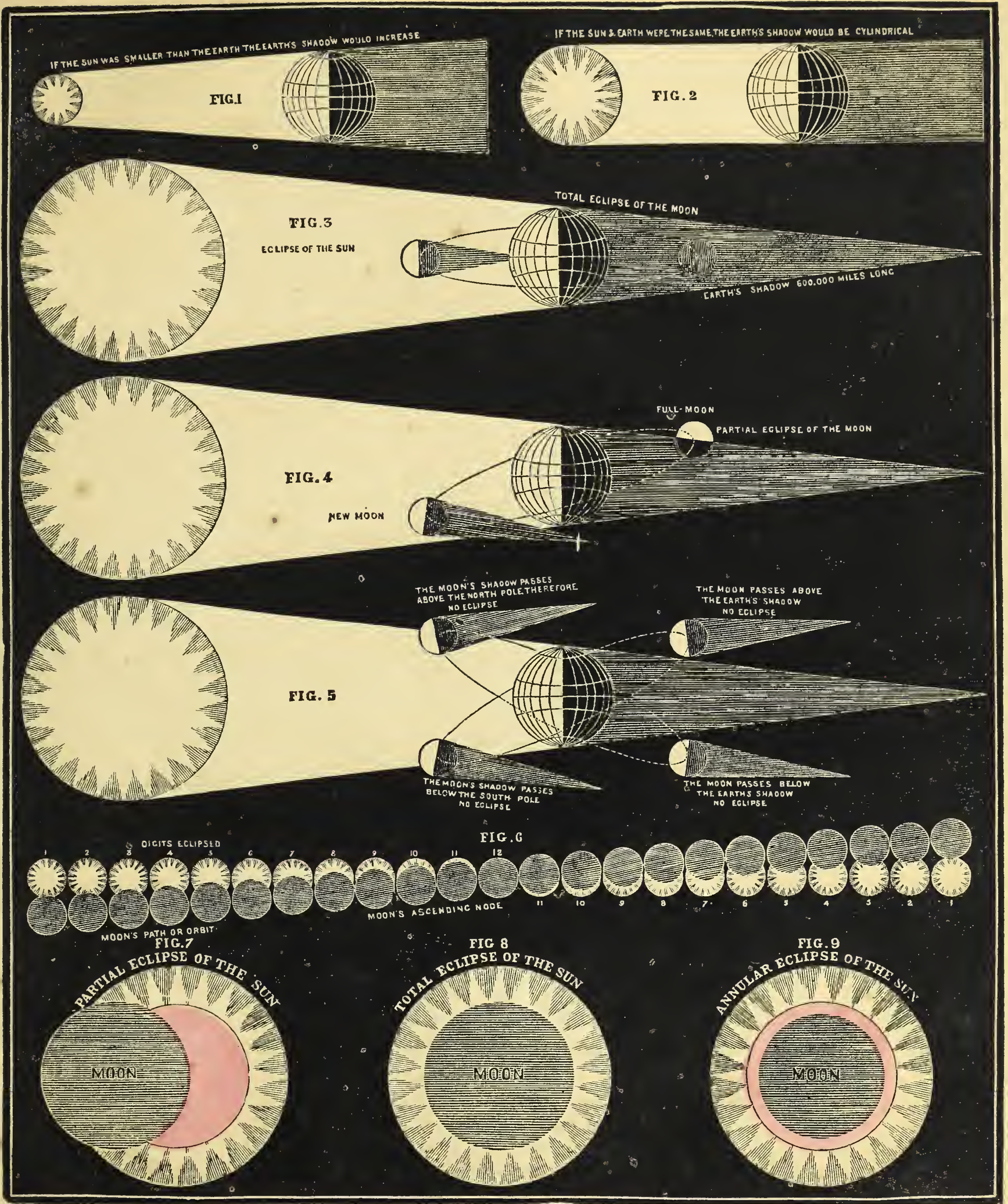
*A.* Two; and both must be of the sun.

### ECLIPSES.

All opake bodies cast a shadow when the rays from any luminous body fall upon them. Every primary and secondary planet in the solar system casts a shadow towards that point of the heavens which is opposite to the sun. If the sun were smaller than the earth, the earth's shadow would increase in diameter as the distance increases from the earth, (See Fig. 1;) but if the sun and earth were of the same size, the shadow would be of the same size, no matter how great the distance from the earth, (See Fig. 2.) But as the sun is immensely larger than the earth, the earth's shadow terminates in a point at about 600,000 miles from the earth; the length of the earth's shadow is, however, subject to considerable variation. When the earth is nearest to the sun, which takes place about January 1st, the shadow is much shorter than when the earth is at its greatest distance, which is about the 1st of July. The moon revolves around the earth in about 29½ days, from one new moon to another. If the moon passed at every new moon exactly between the centres of the sun and earth, we should have a great eclipse of the sun at every new moon, and a total eclipse of the moon at every full moon, (See Fig. 3;) but the moon's orbit or path makes an angle with the plane of the ecliptic, (the plane of the ecliptic is described by a line drawn from the centre of the sun, passing through the centre of the earth and extended to the heavens,) of about 5⅓ degrees, consequently one half of the moon's orbit is above the ecliptic, and the other half is below it.

The two opposite points where the moon's orbit cuts the plane of the ecliptic, are called the moon's nodes; the nodes do not keep in the same position with respect to the earth and sun, but have a retrograde motion of about 19 degrees in a year. This causes the moon at new moon to be too high or too low, so that the moon's shadow passes above the north pole or below the south pole, hence there is no eclipse, and at full moon, the moon passes either above or below the earth's shadow. A total eclipse of the moon occurs when the whole of the moon is immersed in the earth's shadow, (See Fig. 3;) but we occasionally have a partial eclipse of the moon which is caused by the moon's being so high or so low as only to be partially immersed in the earth's shadow, (See Fig. 4.) The diameter of the sun and moon's discs is divided into twelve equal parts, called digits (See Fig. 6;) but by inspecting the diagram, it will be seen that when the sun is said to have six digits eclipsed, that only about one third of the disc of the sun is covered by the moon, although one half of the diameter of the sun is hidden from view. The sun and moon appear to be about the same size, but the apparent size of both is subject to some variation: when the earth is in that point of its orbit nearest the sun (January 1st,) the sun appears larger than at any other time during the year, and, when the moon is at the greatest distance from the earth, she appears the smallest. If an eclipse of the sun should take place exactly at this time, the shadow of the moon would terminate in a point before it reached the earth, and the moon would not appear large enough to cover the whole disc of the sun, but would produce what is called an annular eclipse, or the sun would appear like a luminous ring around the moon, (See Fig. 9;) but if the earth was at its greatest distance from the sun (July 1st) and the moon the nearest to the earth, then the moon would appear larger than the sun, and the shadow of the moon would touch the earth before it terminated in a point; this would produce a total and as great an eclipse of the sun as can take place, (See Fig. 3.) A total eclipse of the sun is visible only to a small portion of the earth at one and the same time, the shadow of the moon where it touches the earth would be only about 150 miles in diameter, consequently there would be only a space across the earth from west to east about 150 miles wide, in which it would appear total, but, a partial eclipse would be seen from a space more than 2,000 miles wide on each side of the umbra, or dark shadow. Those who lived north of the dark shadow would see the southern portion of the sun eclipsed, and those who lived south of it, would see the northern limb of the sun eclipsed.

Eclipses of the sun are more frequent than of the moon, because the sun's ecliptic limits are greater than the moon's, yet we have more visible eclipses of the moon than of the sun, because eclipses of the moon are visible from all parts of the earth where the moon is above the horizon, and are equally great to each of those parts; but eclipses of the sun are visible only to those places upon which the moon's shadow falls.


IF THE SUN WAS SMALLER THAN THE EARTH THE EARTH'S SHADOW WOULD INCREASE
FIG.1
IF THE SUN & EARTH WERE THE SAME THE EARTH'S SHADOW WOULD BE CYLINDRICAL
FIG. 2
FIG. 3
ECLIPSE OF THE SUN
TOTAL ECLIPSE OF THE MOON
EARTH'S SHADOW 600,000 MILES LONG
FIG. 4
FULL-MOON
PARTIAL ECLIPSE OF THE MOON
NEW MOON
FIG. 5
THE MOON'S SHADOW PASSES ABOVE THE NORTH POLE THEREFORE NO ECLIPSE
THE MOON PASSES ABOVE THE EARTH'S SHADOW NO ECLIPSE
THE MOON'S SHADOW PASSES BELOW THE SOUTH POLE NO ECLIPSE
THE MOON PASSES BELOW THE EARTHS SHADOW NO ECLIPSE
FIG. 6
DIGITS ECLIPSED
1 2 3 4 5 6 7 8 9 10 11 12
11 10 9 8 7 6 5 4 3 2 1
MOON'S ASCENDING NODE
MOON'S PATH OR ORBIT
FIG. 7
PARTIAL ECLIPSE OF THE SUN
MOON
FIG 8
TOTAL ECLIPSE OF THE SUN
MOON
FIG. 9
ANNULAR ECLIPSE OF THE SUN
MOON

### ECLIPSES.—Continued.

*Question.* Why are there more eclipses of the Sun than of the Moon?

*Answer.* Because the Solar Ecliptic Limit is 10° degrees greater than that of the Moon.

*Q.* Are visible eclipses of the Moon more frequent at any particular place, than those of the Sun?

*A.* They are; because an eclipse of the Moon is visible and appears as great to all places on the Earth where the Moon is above the horizon.

*Q.* Why are not visible eclipses of the Sun as frequent as those of the Moon?

*A.* Because an eclipse of the Sun is visible only at those places on the Earth where the Umbra or Penumbra falls.

*Q.* What is the Umbra of the Earth, Moon or any other planet?

*A.* It is the *total dark shadow* of the planet, see Fig. 1, 2, 3, 4.

*Q.* What is the Penumbra?

*A.* It is a faint shadow surrounding the Umbra, Fig. 1, 2, 3, 4.

*Q.* What is the extent of the Moon's Umbra upon the Earth when greatest?

*A.* It never can exceed 175 miles in diameter, and it generally is much less, see Fig. 3.

*Q.* Why do eclipses of the Sun always begin on the western side of the Sun?

*A.* Because the Moon passes from west to east between the Earth and Sun.

*Q.* Why do eclipses of the Moon begin on the eastern side of the Moon?

*A.* Because the Moon passes from west to east through the Earth's shadow, see Fig. 1.

*Q.* In what direction does the Moon's shadow pass over the Earth in a Solar Eclipse?

*A.* It passes over the earth from west to east.

*Q.* How large a portion of the Earth's surface may be covered by the Moon's Penumbra?

*A.* A space about 4,393 miles in diameter.

*Q.* Why are not all eclipses of the Sun total?

*A.* Because the Moon being so far from the Earth, its shadow terminates in a point before it reaches the earth, see Fig. 2.

*Q.* In what point of its orbit must the Moon be to cause a total eclipse of the Sun?

*A.* It must be at or near its *perigee,* when the Umbra of the Moon would reach the Earth, see Fig. 3.

*Q.* How long may an eclipse of the Moon continue?

*A.* It may continue four hours; in this case the Moon must pass directly through the centre of the Earth's shadow, see Fig. 1.

*Q.* Is the Moon ever visible when it is totally eclipsed?

*A.* It is, and appears of a reddish color like tarnished copper.

*Q.* What causes the Moon to be visible when it is totally eclipsed?

*A.* The rays of the Sun in passing through the atmosphere of the Earth are refracted or turned out of their course and falling upon the Moon render it faintly visible.

*Q.* What are the effects of a total eclipse of the Sun?

*A.* The heavens are shrouded in darkness, so that the stars and planets become visible; the animal tribes become agitated; and a general gloom overspreads the landscape.

*Q.* How long can a total eclipse of the Sun continue at any one place on the earth?

*A.* A total eclipse of the Sun cannot continue at any one place over four minutes.

*Q.* Why is the dark portion of the New Moon visible when seen in the west soon after the Sun is set?

*A.* Because the rays of the Sun falling upon the Earth are reflected back upon the dark portion of the Moon and render it faintly visible, see Fig. 4. [This appearance of the Moon at new moon is sometimes called "*the Old Moon in the New Moon's arms.*"]

*Q.* Are the Stars or planets ever hidden from our view by the Moon?

*A.* They frequently are, which is called the Occultation of a star or planet.

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### ECLIPSES.

Eclipses are among the most interesting phenomena presented to us by the heavenly bodies. In all ages, when an eclipse has taken place, it has excited the profound attention of the learned, and the fears and superstitions of the ignorant. The causes of eclipses before the seventeenth century were known only to a few, and they generally took advantage of this knowledge to impose upon the credulity of the ignorant by pretending that they were inspired by the Gods. Among the ancient nations, the Chaldeans were the foremost in their observations of the phenomena of the heavens; perhaps this was owing in some measure to their occupation; They being shepherds were obliged to watch their flocks by night to protect them from the wild beasts which were at that time numerous. Men under such circumstances would naturally be led to watch closely the movements of the heavenly bodies, and more especially so; for in the earlier periods of the world they had no correct mode of reckoning time in order to determine the seasons or the proper seed time and harvest.

Eclipses attracted the particular attention of the Chaldeans, and by a series of observations extended through several centuries, they discovered a very important fact relating to eclipses although they did not understand the cause.

By comparing the records which had been made for a great length of time, they found that a certain period of time elapsed between eclipses of the same kind and magnitude; that is, if 18 years, 11 days, 7 hours and 43 minutes, were added to the time of the happening of any eclipse, it would show the time of the return of the same eclipse; the only differences would be that it would not happen at the same time in the day and it would be a little greater or less than the previous eclipse—thus they were able to predict eclipses with sufficient accuracy to answer their designs upon the ignorant without understanding the laws by which these periodical returns were produced.

To explain this briefly, it must be remembered that the moon's orbit makes an angle with the plane of the earth's orbit of $5\frac{1}{3}°$; these two points where the moon's orbit cuts the plane of the earth's orbit, are called nodes, (see diagram, greatest number of eclipses in one year, page 45). Now we will suppose that on any day at noon it is new moon, and the moon is just 16° degrees from her descending node, the shadow of the moon would just *touch* the earth at the north pole; in 223 lunations or 18 years, 11 days, 7 hours, 43 minutes thereafter, the moon would come nearly to the same position as it was at the beginning, consequently there would be another small eclipse of the Sun, and at the expiration of every 223 lunations it would return, and at each return the moon's shadow would pass across the earth a little more to the south until the eclipse had appeared about 77 times, when it would pass off at the south pole, occupying a period of 1388 years: The same period would not commence again until the expiration of 12192 years. Each eclipse which takes place during any year, belongs to a separate and similar period. Those periods of eclipses which come in at the Moon's ascending node, first come on to the earth at the south pole and at each return the moon's shadow passes across the earth more to the north and after appearing about 77 times they finally leave the earth at the north pole.

In those periods of eclipses of the moon which come in at the moon's descending node, the moon first touches the upper portion of the earth's shadow and at each return the moon passes through the earth's shadow more to the south and at the thirty-second return the moon would pass directly through the centre of the earth's shadow, producing a great eclipse of the moon; also in those eclipses of the moon which come in at the moon's ascending node, the moon first comes in contact with the lower portion of the earth's shadow and at each return the moon passes through the shadow more to the north and goes through a similar course as in the former case; it must be remembered that there are a number of eclipses in each year, the greatest number is seven the least two; but the eclipses which happen in any one year cannot take place again until the expiration of 18 years, 11 days, 7 hours, 43 minutes.

# ECLIPSES OF THE SUN & MOON.

## LESSON XXXVII.

### MOON'S NODES.

*Question.* What are nodes?

*Answer.* They are two opposite points where the orbit of the moon, or any other planet intersects the plane of the earth's orbit or ecliptic.

*Q.* What angle does the moon's orbit make with the plane of the earth's orbit or ecliptic.

*A.* About $5\frac{1}{7}$ degrees. (5° 8′ 48″.)

*Q.* What part of the moon's orbit is above or north of the plane of the earth's orbit?

*A.* One half, the other half being below, or south of the earth's orbit?

*Q.* What is the ascending node?

*A.* It is that point where the moon passes the plane of the earth's orbit from south to north.

*Q.* What is the descending node?

*A.* It is that point where the moon passes the plane of the earth's orbit from north to south.

*Q.* Do the nodes change their position as regards a fixed point in the heavens?

*A.* They have a retrograde motion of about 19 degrees in a year.

*Q.* When is the moon in north latitude in the heavens?

*A.* When it is north of the earth's orbit or ecliptic.

*Q.* When is the moon in south latitude in the heavens?

*A.* When it is south of the earth's orbit or ecliptic.

*Q.* What is the greatest latitude of the moon?

*A.* $5\frac{1}{7}$ degrees north or south of the earth's orbit or ecliptic.

*Q.* What is the greatest declination of the moon, or its distance north or south of the equinoctial or equator?

*A.* About $28\frac{1}{2}$ degrees.

## LESSON XXXVIII.

*Q.* How near one of the nodes must the moon be at new moon to cause an eclipse of the sun?

*A.* Within seventeen degrees. (16° 59″.)

*Q.* How near one of the nodes must the moon be at full moon to cause an eclipse of the moon?

*A.* About 12 degrees. (11° 25′ 4″.)

*Q.* If the moon is exactly in one of her nodes at new or full moon, what kind of an eclipse will it cause?

*A.* It will cause a great eclipse of the sun or moon.

*Q.* What is the extent of the solar ecliptic limit in which an eclipse of the sun can take place?

*A.* Thirty-four degrees, seventeen degrees on each side of either node.

*Q.* What is the extent of the lunar ecliptic limit in which an eclipse of the moon can take place?

*A.* Twenty-four degrees, twelve on each side of either node.

#### INFERIOR AND SUPERIOR CONJUNCTION.

*Q.* How many kinds of conjunction are there?

*A.* Two; inferior and superior.

*Q.* When is a planet in inferior conjunction with the sun?

*A.* When it is between the earth and sun.

#### CONJUNCTION.—Continued.

*Q.* What planets can be in inferior conjunction?

*A.* Mercury and Venus; also the moon.

*Q.* When are two planets in superior conjunction?

*A.* When they are on opposite sides of the sun.

*Q.* What planets can be in superior conjunction with the sun?

*A.* All the planets, except the earth and moon.

## LESSON XXXIX.

#### INFERIOR AND SUPERIOR PLANETS.

*Q.* How are the primary planets divided?

*A.* They are divided into two classes, inferior and superior.

*Q.* Which are the inferior planets?

*A.* Mercury and Venus.

*Q.* Why are they called inferior planets?

*A.* Because their orbits are within the orbit of the earth.

*Q.* Which are the superior planets?

*A.* Mars, "*the Asteroids,*" Jupiter, Saturn, Herschel and Leverrier.

*Q.* Why are they called superior planets?

*A.* Because their orbits are greater than the orbit of the earth.

#### HELIOCENTRIC AND GEOCENTRIC LATITUDE AND LONGITUDE.

*Q.* What is the Heliocentric latitude and longitude of a planet?

*A.* It is its latitude and longitude, as seen from the sun. (See Diagram.)

*Q.* What is the Geocentric latitude and longitude of a planet?

*A.* It is its latitude and longitude as seen from the earth.

*Q.* Does a planet, seen from the earth, appear to have the same longitude as it would have if seen from the sun at the same time?

*A.* It does not, unless the earth is between the sun and planet.

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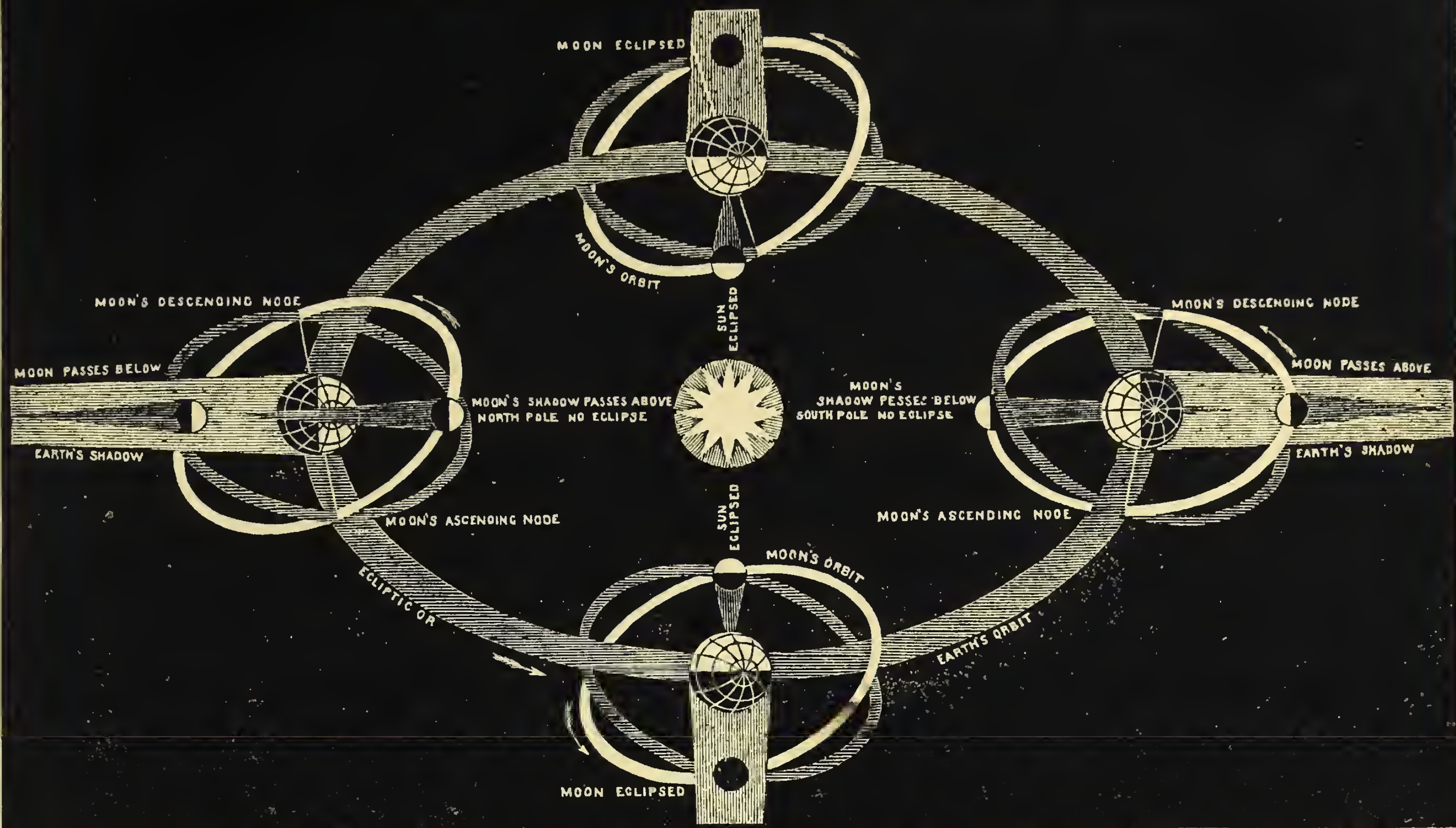
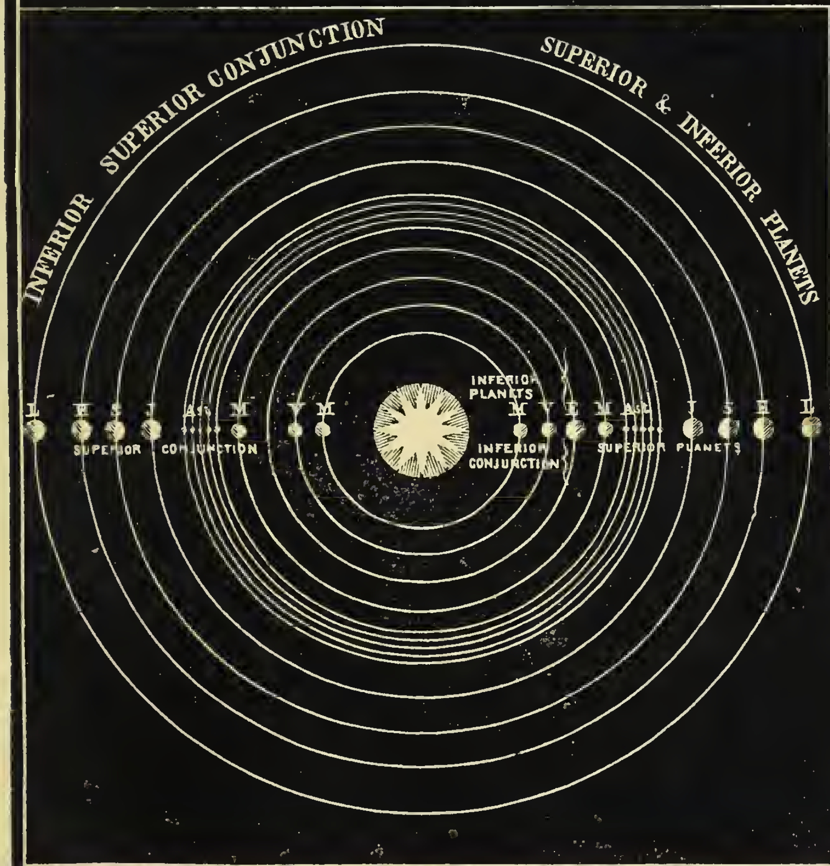
It will be seen by inspecting the diagram upon the opposite page, that there are two small circles introduced into the diagram, the white circle which represents the moon's orbit, and the shaded circle which lies in the plane of the earth's orbit or ecliptic; this shaded circle is introduced into the diagram only to show the two points where the moon's orbit intersects the plane of the earth's orbit or ecliptic; these two points are called the moon's nodes; the point where the moon passes from the south to the north side, or above the earth's orbit, is called the ascending node; and the opposite point, or where the moon descends below the earth's orbit, is called the descending node; the line passing through the centre of the earth from one node to the other, is called the "*line of the nodes.*" It will be seen also that one half of the moon's orbit is above the plane of the earth's orbit, and the other half below it.

The planets *Mercury* and *Venus* are called inferior planets, because their orbits are within that of the earth, and of course nearer to the sun. The other primary planets, Mars, Asteroids, Jupiter, Herschel and Leverrier, are called superior planets for the same reason that their orbits are greater, or outside that of the earth.

It will be seen by inspecting the diagram upon the opposite page, that the planets, seen by two observers at the same time, one upon the sun and the other upon the earth, would not appear to be exactly in the same point of the heavens. The heliocentric longitude of a planet is where it would appear to be if seen from the sun, and the geocentric longitude of a planet is its longitude as seen from the earth.

# MOONS NODES, ECLIPSES, &C.




# LESSON XL.

## GREATEST NUMBER OF ECLIPSES IN A YEAR.

*Question.* What is the greatest number of eclipses that can take place in a year?

*Answer.* Seven; five of the sun and two of the moon.

*Q.* What is the least number of eclipses that can take place in a year?

*A.* Two; both of the sun.

*Q.* What must be the position of the moon and her ascending node, on the first day of January, to cause seven eclipses in a year?

*A.* It must be new moon, and the moon must be within 17 degrees of her ascending node at the time.

*Q.* When would the second eclipse take place?

*A.* The second eclipse would be of the moon, January 15th, at her descending node.

*Q.* When would the third eclipse take place?

*A.* The third eclipse would be of the sun, January 29th, at the moon's ascending node.

*Q.* When the fourth eclipse?

*A.* The fourth eclipse would be of the sun, June 26th, at the moon's descending node.

*Q.* When the fifth eclipse?

*A.* The fifth eclipse would be of the moon, July 11th, at her ascending node.

*Q.* When the sixth eclipse?

*A.* The sixth eclipse would be of the sun, July 25th, at the moon's descending node.

*Q.* When the seventh and last eclipse?

*A.* The seventh eclipse would be of the sun, December 20th, at the moon's ascending node.

*Q.* Why are there no eclipses in this case from January 29th to June 26th?

*A.* Because the moon is so high at new moon that its shadow passes above the north pole, and at full moon, the moon passes below the earth's shadow.

*Q.* Why are there no eclipses in this case from July 25th to December 20th?

*A.* Because the moon is so low at new moon, that its shadow passes below the south pole, and at full moon, the moon passes above the earth's shadow.

*Q.* What must be the position of the moon and her ascending node, on the 1st day of January, to cause only two eclipses during the year?

*A.* It must be new moon, and the moon must be in or very near her ascending node.

*Q.* How often are there seven, or only two eclipses in a year?

*A.* Not oftener than once in a hundred years.

*Q.* What is the most common number of eclipses in a year?

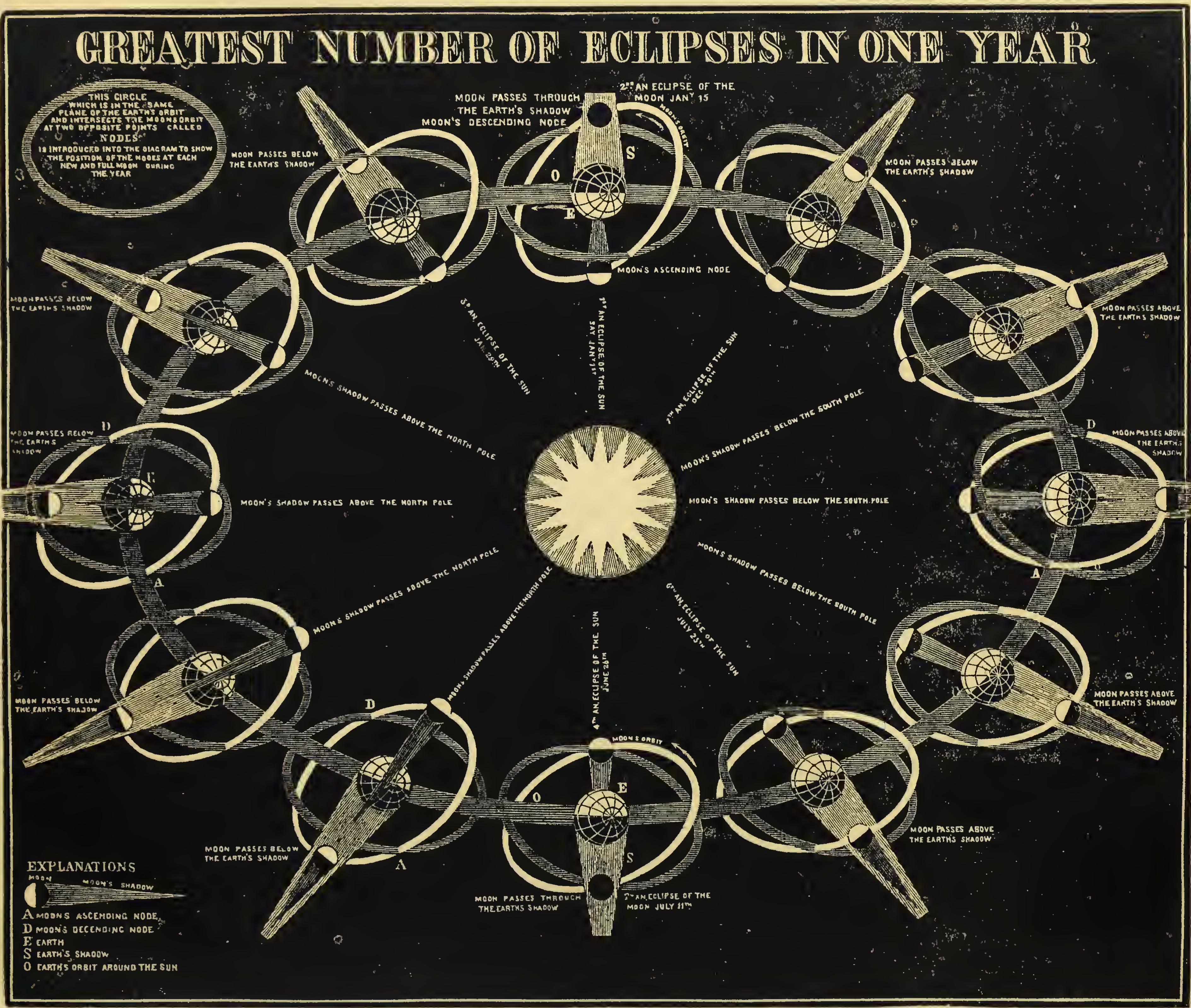
*A.* Four.

### Greatest Number of Eclipses in a Year.

When the moon is within 17 degrees of either node at new moon, it will cause an eclipse of the sun, and when the moon is within 12 degrees of either node at full moon, the moon will then be more or less eclipsed. If the line of the nodes were carried parallel to itself around the sun, there would be just half a year from the time of one node passing the sun, to the other's coming around to the sun; but as the nodes have a retrograde motion of about nineteen degrees in a year, it is only 177 days from the conjunction of one node to the conjunction of the other, therefore, in whatever time of the year we have eclipses of the sun or moon at either node, we may be sure that in 177 days, we shall have eclipses about the other node. If we suppose the moon at new moon to be 17 degrees from her ascending node on the first day of January, there would be a small eclipse of the sun, and at the next full moon, January 15th, there would be a total eclipse of the moon; as the moon would be only about 2 degrees from the descending node; at the next new moon, January 29th, the moon would then be about 12 degrees upon the other side of the ascending node, which would cause another small eclipse of the sun,—hence we would have two small eclipses of the sun at the ascending node, and one great eclipse of the moon at the descending node, from January 1st to January 29th. (See Diagram.) At every subsequent new moon, the moon would be so high that the shadow would pass above the north pole, and at every full moon, the moon would pass below the earth's shadow, until June 26th, when the moon's descending node would come around to the sun, (see Diagram;) at this time the moon would be about 7 degrees from her descending node; this would cause another eclipse of the sun. At the next full moon, July 11th, there would be another total eclipse of the moon; again, at the next new moon, July 25th, the moon would still be within 17 degrees of her descending node, which would produce another small eclipse of the sun.

From July 25th, there would be no eclipses of the sun or moon, as at every subsequent new moon, the moon would be so low that the shadow of the moon would pass below the south pole, and at every full moon the moon would pass above the earth's shadow, until December 20th, when the ascending node would come around again to the sun, and at the 12th new moon in the year, the moon would again be within 17 degrees of her ascending node; we would, therefore, have another small eclipse of the sun, which would be the seventh and last eclipse during the year. It will be seen from the above, that we should have five eclipses of the sun, and two total eclipses of the moon, during the year, which is the greatest number that can possibly take place in a year. Seven eclipses in a year do not occur twice in a hundred years, although perhaps we may have seven eclipses in one year's time, for several times during a century. To have seven eclipses during the same year, it is necessary that the moon and nodes be in a particular position on the first day of January.

After the sun, moon and nodes have been once in a line of conjunction; they return nearly to the same position again in 223 lunations or 18 years 11 days 7 hours 43 minutes 20 seconds, when four leap years are included, or one day less, when five leap years are included; consequently, if to the mean time of any eclipse of the sun or moon, we add 18 years 11 days 7 hours 43 minutes 20 seconds, we shall have the mean time of the return of the same eclipse for a long period of time. This period was first discovered by the Chaldeans, by a long series of observations, extending through many centuries, and by it they were able to foretell, with considerable exactness, the appearance of an eclipse, varying at most but a few hours. Every eclipse within this period of 18 years, belongs to a separate series of eclipses, that is, there is but one eclipse during the 18 years, which belongs to the same series. If any series of eclipses commence at the ascending node, the shadow of the moon just touches the earth at the north pole; at the next return in 18 years, the shadow will pass across the earth a little more to the south, and at each return, the shadow will continue to pass more to the south until it will have appeared about 77 times, which will take about 1,388 years, when it will pass off the earth at the south pole, and at the expiration of 12,492 years, the same eclipses will commence again to go through a similar course. Those eclipses of the sun which come in at the descending node, the shadow of the moon first touches the earth at the south pole, and at each return passes more to the north, and finally leaves the earth at the north pole, after having appeared the usual number of times. The velocity of the moon's shadow across the earth in an eclipse of the sun is about 1,850 miles an hour, or about four times the velocity of a cannon ball. The moon when totally eclipsed, is generally visible if it is above the horizon, and the sky is clear: it generally appears of a faint dusky red, or copper color, this is caused by the rays of the sun, which pass through the atmosphere of the earth, and are refracted or bent inward, so that some of the rays fall upon the moon and render it visible.


GREATEST NUMBER OF ECLIPSES IN ONE YEAR
THIS CIRCLE WHICH IS IN THE SAME PLANE OF THE EARTH'S ORBIT AND INTERSECTS THE MOONS ORBIT AT TWO OPPOSITE POINTS CALLED NODES IS INTRODUCED INTO THE DIAGRAM TO SHOW THE POSITION OF THE NODES AT EACH NEW AND FULL MOON DURING THE YEAR
MOON PASSES THROUGH THE EARTH'S SHADOW MOON'S DESCENDING NODE
2ND AN ECLIPSE OF THE MOON JAN 15
MOON'S ORBIT
MOON PASSES BELOW THE EARTH'S SHADOW
MOON'S ASCENDING NODE
MOON PASSES BELOW THE EARTH'S SHADOW
MOON PASSES ABOVE THE EARTH'S SHADOW
3RD AN ECLIPSE OF THE SUN JAN 29TH
1ST AN ECLIPSE OF THE SUN SAY JAN 1ST
7TH AN ECLIPSE OF THE SUN DEC 20TH
MOON'S SHADOW PASSES ABOVE THE NORTH POLE
MOON'S SHADOW PASSES BELOW THE SOUTH POLE
MOON PASSES BELOW THE EARTH'S SHADOW
MOON PASSES ABOVE THE EARTH'S SHADOW
MOON'S SHADOW PASSES ABOVE THE NORTH POLE
MOON'S SHADOW PASSES BELOW THE SOUTH POLE
MOON'S SHADOW PASSES ABOVE THE NORTH POLE
MOON'S SHADOW PASSES BELOW THE SOUTH POLE
MOON'S SHADOW PASSES ABOVE THE NORTH POLE
4TH AN ECLIPSE OF THE SUN JUNE 26TH
6TH AN ECLIPSE OF THE SUN JULY 25TH
MOON PASSES BELOW THE EARTH'S SHADOW
MOON PASSES ABOVE THE EARTH'S SHADOW
MOON'S ORBIT
MOON PASSES BELOW THE EARTH'S SHADOW
MOON PASSES ABOVE THE EARTH'S SHADOW
MOON PASSES THROUGH THE EARTH'S SHADOW
5TH AN ECLIPSE OF THE MOON JULY 11TH
EXPLANATIONS
MOON
MOON'S SHADOW
A MOONS ASCENDING NODE
D MOON'S DECENDING NODE
E EARTH
S EARTH'S SHADOW
O EARTH'S ORBIT AROUND THE SUN

## LESSON XLI.

### TIDES.

*Question.* What motion have the earth and moon, besides revolving around the sun?

*Answer.* They revolve around their common centre of gravity?

*Q.* In what part of a straight line joining their centres, is the centre of gravity situated?

*A.* About 3,200 miles from the centre of the earth.

Q. What effect has the centrifugal force upon the water on the opposite side of the earth from the moon?

*A.* It causes it to recede from the centre of gravity, and to rise on that part of the earth.

*Q.* What effect has this upon the shape of the earth?

*A.* Its diameter is lengthened in the line of the moon's attraction, and shortened at right angles to it.

*Q.* What tends to increase this oval shape of the earth?

*A.* The inequality of the attraction of the moon at the different sides of the earth.

[The water upon the side of the earth nearest to the moon, is more attracted than the centre of the earth; the water upon the opposite side is less attracted.]

*Q.* What effect does the turning of the earth, from west to east on its axis, produce?

*A.* It causes these elevations, or tide waves, to pass from east to west around the earth.

*Q.* What is tide?

*A.* It is the rising and falling of the waters of the ocean.

*Q.* How are the tides divided with respect to the rising and falling of the water?

*A.* Into flood and ebb.

*Q.* What is flood tide?

*A.* It is the rising of the water.

*Q.* What term designates the greatest elevation of the flood tide?

*A.* High water.

*Q.* What is ebb tide?

*A.* It is the falling of the water.

*Q.* How often do flood and ebb tide occur?

*A.* Twice in about 25 hours.

*Q.* Do the tides rise at the same hour every day?

*A.* They rise about an hour later each day.

*Q.* Why do the tides rise later?

*A.* Because the moon passes the meridian about an hour later each day.

*Q.* What causes the moon to be later at the meridian?

*A.* It is caused by its revolving monthly around the earth from west to east.

*Q.* Does the attraction of the sun produce an effect similar to that of the moon?

*A.* It tends to raise a tide two fifths as high.

*Q.* When the sun and moon are on the same or opposite sides of the earth, what is the effect of their attractive forces?

*A.* They raise a tide equal to the sum of their separate tides.

*Q.* When they are in quadrature, what is the effect of their counteracting forces?

*A.* They raise a tide equal to the difference of their tides.

## LESSON XLII.

*Q.* How are tides divided with respect to their comparative height?

*A.* Into spring and neap.

*Q.* What is spring tide?

*A.* It is the greatest flood and ebb tide.

*Q.* What is neap tide?

*A.* It is the least flood and ebb tide.

*Q.* What proportion do these tides bear to each other?

*A.* The neap tide is about three sevenths as great as the spring tide.

*Q.* When do spring tides occur?

*A.* Twice in each lunar month, at new and full moon.

*Q.* When do neap tides occur?

*A.* Twice in each lunar month at the quarters.

*Q.* What effect have the continents upon the tide waves when passing round the earth?

*A.* They subject them to great irregularities.

*Q.* Which side of the continents have the highest tides, the eastern or the western?

*A.* The eastern side.

*Q.* Does the water remain permanently higher on the east than on the west side of the continents?

*A.* The gulf of Mexico is 20 feet higher than the Pacific ocean, and the Red sea is 30 feet higher than the Mediterranean.

*Q.* Where the tide wave is least obstructed, as in the Pacific ocean, how much behind the moon is it?

*A.* It is two or three hours behind it.

*Q.* How long after the moon passes the meridian, is it high water at New York?

*A.* About 8½ hours.

*Q.* If the earth were uniformly covered with water, how high would the tide rise?

*A.* Not more than two or three feet. (The tide at the small islands in the Pacific ocean is usually less.)

*Q.* What produces the greatest effect in causing high tides?

*A.* The shape of the land, and the position of the shores.

*Q.* Where are the highest tides in the world?

*A.* In the bay of Fundy.

*Q.* What, besides the position of the shores, tends to raise a high tide at this place?

*A.* The meeting of the tide wave from the North Atlantic ocean, with the main one from the South Atlantic.

*Q.* How high are the average spring tides at Cumberland near the head of the bay of Fundy?

*A.* About 71 feet.

*Q.* How high are they at Boston?

*A.* About 11 feet.

*Q.* At New York?

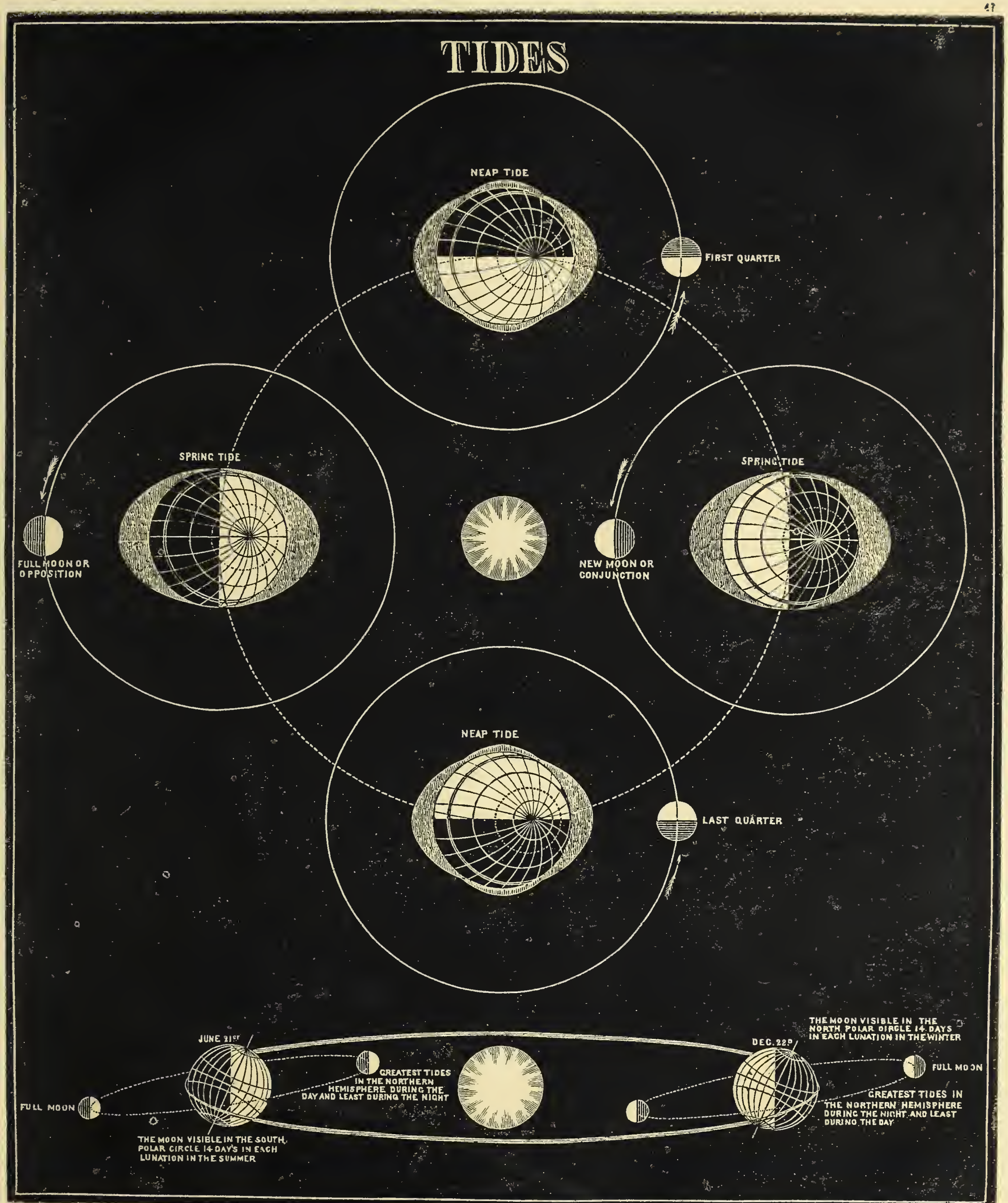
*A.* About 5 feet.

*Q.* At Charleston, South Carolina.

*A.* About 6 feet.

*Q.* When do we have the highest tides in the northern hemisphere?

*A.* At new moon in the summer, and at full moon in the winter. (See Diagram.)


TIDES
NEAP TIDE
FIRST QUARTER
SPRING TIDE
FULL MOON OR OPPOSITION
SPRING TIDE
NEW MOON OR CONJUNCTION
NEAP TIDE
LAST QUARTER
JUNE 21ST
GREATEST TIDES IN THE NORTHERN HEMISPHERE DURING THE DAY AND LEAST DURING THE NIGHT
FULL MOON
THE MOON VISIBLE IN THE SOUTH POLAR CIRCLE 14 DAY'S IN EACH LUNATION IN THE SUMMER
DEC. 22D
THE MOON VISIBLE IN THE NORTH POLAR CIRCLE 14 DAYS IN EACH LUNATION IN THE WINTER
FULL MOON
GREATEST TIDES IN THE NORTHERN HEMISPHERE DURING THE NIGHT AND LEAST DURING THE DAY

## LESSON XLIII.

### ORBITS OF THE PLANETS AND COMETS.

*Question.* WHAT is the orbit of a primary planet?

*Answer.* It is the path in which it revolves around the sun.

*Q.* What is the orbit of a secondary planet?

*A.* It is the path in which it revolves around its primary.

*Q.* What is the form of the orbits of all the planets?

*A.* Elliptical, or longer one way than the other.

*Q.* Are all the orbits elliptical in the same proportion?

*A.* They are not; some are more elongated than others.

*Q.* What is the position of the orbits of all the planets?

*A.* They extend from west to east in the heavens.

*Q.* Do the planes of their orbits, intersect the ecliptic or orbit of the earth?

*A.* They do, at small angles. (See Diagram.)

*Q.* Do they all intersect the plane of the earth's orbit at one point, as represented in the diagram?

*A.* They do not; but intersect it at different points.

*Q.* Through what point does the plane of the orbit, of every primary planet and comet in the solar system, pass?

*A.* Through the centre of the sun.

*Q.* Are the planets at nearly the same distance from the sun?

*A.* They are not, but at very different distances.

*Q.* Are their orbits all contained within the zodiac?

*A.* They are, except those of a part of the asteroids.

*Q.* How wide is the zodiac?

*A.* Sixteen degrees wide: eight degrees on each side of the ecliptic.

*Q.* Do all the planets revolve around the sun in the same direction?

*A.* They do; from west to east.

*Q.* Do they all move with the same velocity?

*A.* The velocity decreases as the distance from the sun increases.

*Q.* Which planet moves in its orbit with the greatest velocity?

*A.* Mercury.

*Q.* Which moves with the least?

*A.* Leverrier, or Neptune.

*Q.* When does a planet have north latitude?

*A.* When it is above, or north of the earth's orbit.

*Q.* When does a planet have south latitude?

*A.* When it is below, or south of the earth's orbit.

## LESSON XLIV.

### COMETS.

*Question.* WHAT are comets?

*Answer.* They are bodies which revolve around the sun in very elongated orbits.

*Q.* How are comets usually distinguished from the planets?

*A.* By a luminous train or tail, on the opposite side from the sun.

*Q.* Is this luminous train always on the opposite side from the sun?

*A.* Not always; a few have been observed to have a different direction.

*Q.* Do comets ever appear without a luminous train?

*A.* Some are entirely destitute of any such appendage.

*Q.* What is the number of comets?

*A.* The number is not known; about 500 have been seen at different times.

*Q.* Are comets solid bodies like the planets?

*A.* They generally are not; although some have been observed to have a dense nucleus, or head

*Q.* What is the nature of comets?

*A.* They are supposed to be gaseous matter, in the form of smoke, fog, or clouds.

*Q.* Do comets shine by their own, or by reflected light?

*A.* They shine by reflected light.

*Q.* Do they all, like the planets, revolve in the same direction around the sun?

*A.* They do not; they revolve in different directions.

*Q.* Are all their orbits within the zodiac?

*A.* They are not; their orbits are in all directions in the heavens.

*Q.* How do many of them move when first seen?

*A.* They appear to move in almost a direct line towards the sun.

Q. Does their velocity increase as they aproach the sun?

*A.* It does; and when near it, they move with immense velocity.

*Q.* How fast has a comet been known to move?

*A.* 880,000 miles an hour.

### Comets.

COMETS were anciently viewed by mankind with astonishment and fear, as being forerunners of dreadful calamities, such as war, famine, or pestilence. Many ancient philosophers considered them as only meteors in the atmosphere. Tycho Brahe was the first who showed that they belonged to the planetary system, and revolved around the sun. The orbits of all the comets are very elliptical, so that they approach the sun almost in a direct line, and after being involved in the light of the sun for a short time, depart from our solar system in nearly the same direction, in which they approached, and remain for years, or even centuries, beyond the limit of the best telescopes.

Very little is known of the *physical nature of comets;* the smaller comets, such as are visible only with telescopes, generally have no appearance of a tail, and appear like round or somewhat oval, vaporous masses, more dense towards the centre; yet they have no distinct nucleus or solid body. Stars of the smallest magnitude are seen through the most dense parts of these bodies. It is very probable that the luminous part of a comet is something of the nature of smoke, fog, or other gaseous matter. Halley's comet, which appeared in 1456, with a tail 60 degrees in length, and spread out like a fan, has appeared periodically every 77th year, viz: 1682, 1759, and in 1836; but it has exhibited no tail, or luminous appendage, since 1456. The comet which appeared 371 years before Christ, is said to have covered a third part of the visible heavens. A remarkable comet made its appearance 43 years before Christ, and was so bright as to be visible in the day time; it was supposed, by the superstitious, to be the ghost of *Cæsar*, who had just been assassinated. The following are some of the most remarkable comets:—

| | | | | | |
|---|---|---|---|---|---|
| Comet of | 1680, | length of the tail | | 123,000,000 | miles. |
| Do. | 1744, | " | " | 35,000,000 | " |
| Do. | 1769, | " | " | 48,000,000 | " |
| Do. | 1811, | " | " | 130,000,000 | " |
| Do. | 1843, | " | " | 130,000,000 | " |


ORBITS OF THE PLANETS
DRAGON
LESSER BEAR
CAMELEOPARD
NORTH STAR
HARP
HERCULES
LYNX
BULL
WAGGONER
SHIELD
ARCHER
TWINS
CROWN
ORION
TELESCOPE
HARE
PEACOCK
GREAT DOG
OCTANT
NOAHS DOVE
SWORD FISH
EASEL
AXIS OF THE ECLIPTIC
AXIS OF THE EQUINOCTIAL
COMET
COMET
EQUINOCTIAL
JUNO
VESTA 7° 8′ 46″
VENUS
MARS
HERSCHEL
EARTH
JUPITER
SATURN
MERCURY
CERES 10° 37′ 34″
PALLAS

## COMETS.—Continued.

*Question.* What are the principal parts of a comet?

*Answer.* The Nucleus, the Envelope and the Tail.

*Q.* What is the Nucleus?

*A.* It is the most dense or solid portion, sometimes called the head. (See the comet of 371.)

*Q.* What is the Envelope?

*A.* It is a luminous matter surrounding the Nucleus.

*Q.* What is the Tail of of a comet?

*A.* It is a long luminous train extending off from the head in the opposite direction from the sun. (See Note 1.)

*Q.* What effect has the eccentricity of their orbits upon the motion of the comets? (See Note 2.)

*A.* Their motion increases as they approach the *sun* and decreases as they recede from the sun.

*Q.* What effect has the change of position upon their appearance?

*A.* Their *tails* usually increase both in length and breadth as they approach the *sun* and contract as they recede from the sun.

*Q.* Is any thing known of their *Temperature?*

*A.* They must be very hot when near the sun. (See Note 3.)

*Q.* What can you say of the size of comets?

*A.* Their Nuclei or heads are usually small, being only from 33 to 2000 miles in diameter.

*Q.* Do all the comets revolve around the *Sun* continually?

*A.* *Professor* Nichol and Sir John Herschel are of opinion that the greater number visit our System but once, and then fly off in nearly straight lines till they pass the center of attraction between the Solar System and Fixed Stars, and go to revolve around suns in the far distant heavens.

*Q.* How were comets regarded by the *ancients?*

*A.* As harbingers of famine, pestilence, war and other dire calamities. (Note 4.)

*Q.* What other fears have been entertained of comets?

*A.* That they might come in collision with our globe and dash it to pieces or burn every thing from its surface.

*Q.* Is there really any danger of a comet striking the Earth?

*A.* It has been determined upon mathematical calculations that there is not more than 1 in 281,000,000 of chances for a comet to strike the Earth.

*Q.* What would be the effect if a comet should strike the Earth?

*A.* The only effect it would produce, is that it might infuse a gaseous matter into our atmosphere which might produce disease or death. (Note 5.)

*Q.* What is known of the Periodic times of comets?

*A.* The revolution of only four has been determined. [Enck's comet, $3\frac{1}{2}$ years; Biela's comet, $6\frac{3}{4}$ years; Halley's comet, 76 years; Comet of 1680, 570 years.

### NOTES.

Note 1.—Comets assume a great variety of shapes; some appearing like an enormous *fan*, others like a long sword or sabre; but all curved more or less, and concave towards the regions from which they come. The Comet of 1744, represented on the opposite page, excited great attention.

Note 2.—The orbits of Comets are very elongated, having their *perihelion* very near the Sun; (see diagram, page 45,) consequently as they approach the Sun their velocity increases rapidly by the increased attraction of the Sun, and when at their *perihelion* they move with immense velocity.

Note 3.—The Comet of 1680, came within 130,100 miles of the Sun, and must have received 28,000 times more light and heat than the earth receives from the Sun. Sir Isaac Newton calculated the heat of this Comet to be 2,000 times greater than *red hot iron*, and that it would require 2,000 years to cool; he assumed that the Comet was a solid body, which was not the *fact*. It is a generally conceded *fact* at the present day that the rays of the Sun to produce much heat, must come in contact with solid bodies; and as Comets are of an extremely thin gaseous matter the rays of the Sun may pass through them without producing much heat, this is more probably the case. We find in ascending high mountains that the atmosphere becomes very cold which ought not to be the case if the rays of the *Sun* impart much heat to the atmosphere in their passage through it. It is only when the rays of the Sun come in contact with the earth that much heat is produced. The density of comets is probably not so great as that of our atmosphere and as they have no solid Nucleus or heads, the probability is that comparatively very little heat is produced by their near approach to the Sun.

Note 4.—The Comet of 1811, was regarded by the ignorant as the precursor of the *War* that was declared in the following spring between Great Britain and the United States. In some cases Comets have excited fears that the day of judgment was at hand and that the comet was sent to *burn up the world*. In 1773, M. Delande of Paris announced to the Academy that there was great danger of the Comet which was soon to appear, striking the earth. It is said that in consequence of this announcement when the Comet appeared, many persons of weak minds died of *fright*.

Note 5.—A Comet by striking the earth would produce no more effect upon the motions of the earth than the clouds do in striking against high mountains; besides our atmosphere would oppose a powerful resistance, being more dense than the comets, it is very doubtful, should a Comet strike the earth that it would penetrate to its surface; but it is more probable that it would be retained in the upper portions of our atmosphere. It is very probable that comets contain no aqueous vapors; but are simply of a gaseous matter, and it does not follow from this that it would produce any evil consequences if it should be incorporated with our atmosphere.

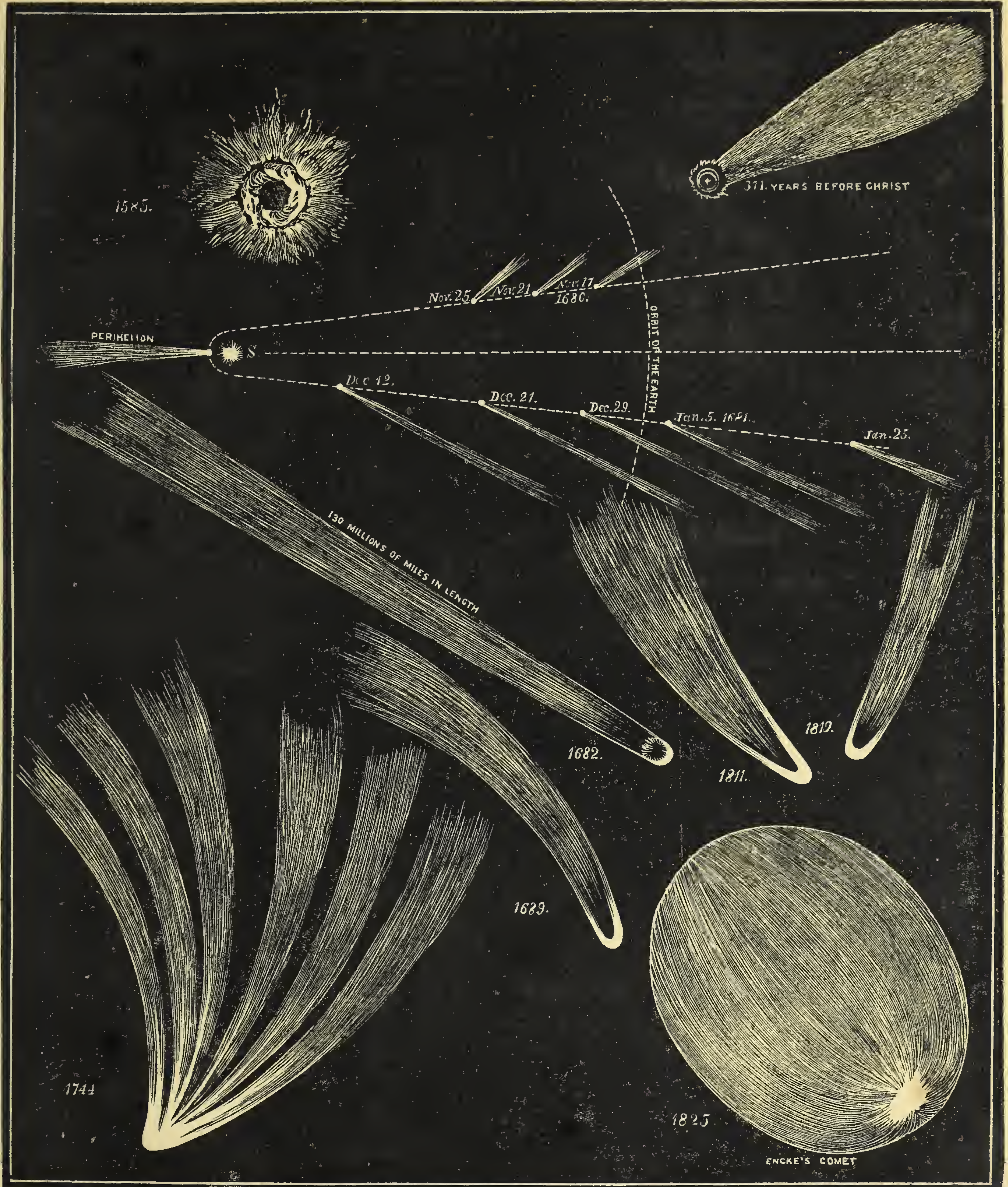
### HAS THE EARTH PASSED THROUGH THE TAILS OF COMETS?

It has been asserted by some astronomers that the Earth has on several occasions passed through the Tail of a comet, and in proof of this fact several cases of a singular or peculiar kind of *Fog* have been noticed at several periods. The first of which any record is made was that of 1783, it began on the 18th of June and at places very remote from each other. It extended from Africa to Sweden and throughout North and South America. This *Fog* continued more than a month. It did not appear to be carried to different places by the atmosphere; because in some places it came on with a north wind and at others with a south or east wind, it prevailed in the highest summits of the Alps as well as in the lowest valleys. The rains which were very abundant in June and July did not appear to disperse it in the least. In Languedoc its density was so great that the Sun did not become visible in the morning till it was twelve degrees above the horizon; it appeared very red during the rest of the day and might be looked at with the naked eye. This *Fog* or *Smoke* had a disagreeable smell and was entirely destitute of any moisture, whereas most fogs are moist; besides all this there was one remarkable quality in the *Fog* or *Smoke* of 1783, it appeared to possess a *phosphoric* property or a light of its own; We find by the accounts of some observers, that it afforded even at mid-night a light equal to that of the full moon, and which was sufficient to enable a person to see objects distinctly at a distance of two hundred yards, and to remove all doubts as to the source of this light, it is recorded that at the time there was a *New Moon*.

Another remarkable *Fog* in 1831, which excited the public mind in all quarters of the globe, resembled so much that of 1783, that the description given of it, applies with equal force to that of 1831.

*Now let us look at the facts.* It must be acknowledged by all that these *Fogs* originated from some uncommon cause; now the next question is, to what causes shall we attribute the *fogs* of 1783 and 1831. Some have supposed that they were caused by irruptions of *Mount Hecla* in Iceland, others have advanced the idea that an immense *fire ball* in penetrating our atmosphere was there but partially ignited, and that torrents of smoke were deposited in the higher regions of our atmosphere and finally diffused through it.

These explanations are very unsatisfactory. If the *Fogs* were actually produced by the earth's passing through any portion of a comet, we have no cause of fear from these bodies which have been for centuries a *terror* and *dread* to mankind generally. We will concede that it is the fact that these Fogs were produced by comets until we have a better explanation of their origin.


1585.
371. YEARS BEFORE CHRIST
Nov. 25.
Nov. 21
Nov. 11
1680.
PERIHELION
S
ORBIT OF THE EARTH
Dec. 12.
Dec. 21.
Dec. 29.
Jan. 5. 1681.
Jan. 25.
130 MILLIONS OF MILES IN LENGTH
1682.
1811.
1819.
1689.
1744
1825
ENCKE'S COMET

## LESSON XLV.

### ATMOSPHERE.

*Question.* What is air?

*Answer.* It is an elastic, invisible fluid, which surrounds the earth.

*Q.* Of what, besides air, is the atmosphere composed?

*A.* Of vapor, carbonic acid, and other gases.

*Q.* Is the atmosphere of the same density as we ascend from the earth?

*A.* It grows thinner or less dense.

*Q.* What is the estimated hight of the atmosphere?

*A.* About forty-five miles.

*Q.* What is the pressure of the atmosphere upon the earth?

*A.* Nearly fifteen pounds to the square inch. (14.6.)

*Q.* What is the weight of air compared with water?

*A.* It is 816 times lighter than water.

*Q.* The pressure of the atmosphere is equal to a column of water, of what height?

*A.* Thirty-three feet.

*Q.* Of what is air composed?

*A.* Of oxygen and nitrogen gases.

*Q.* In what proportions?

*A.* Twenty parts of oxygen to eighty parts of nitrogen.

## LESSON XLVI.

### REFRACTION.

*Question.* What is refraction?

*Answer.* It is the deviation of the rays of light from a straight line.

*Q.* What is astronomical refraction?

*A.* It is the deviation of the rays of light in their passage through the atmosphere.

*Q.* What is the cause of this refraction?

*A.* It is caused by the increase of the density of the atmosphere towards the earth.

*Q.* In what part of the heavens is the light of a body most refracted?

*A.* In the horizon.

*Q.* What effect does this refraction have upon the sun at its rising and setting?

*A.* It makes the sun appear above the horizon when it is actually below it. (See Diagram.)

*Q.* Does this affect the length of the day?

*A.* It makes the day from six to ten minutes longer, from sun rise to sun set.

*Q.* Is the light of a body refracted when it is in the zenith?

*A.* It is not. (See Diagram.)

*Q.* What is twilight?

*A.* It is that faint light, seen before the sun rises and after it sets.

*Q.* What is the cause of twilight?

*A.* It is caused by the atmosphere's reflecting the light of the sun.

*Q.* Twilight ceases when the sun is, how far below the horizon?

*A.* Eighteen degrees.

## LESSON XLVII.

### PARALLAX.

*Question.* What is parallax?

*Answer.* It is the difference between the apparent and true place of a heavenly body.

*Q.* What is the apparent place of a planet?

*A.* It is the place where it appears to be when seen from the surface of the earth.

*Q.* What is the true place of a planet?

*A.* It is the place where it would appear to be if seen from the centre of the earth, or centre of motion.

*Q.* Where is the parallax of a heavenly body the greatest?

*A.* At the horizon, and decreases to the zenith.

*Q.* How are parallaxes divided?

*A.* They are divided into two kinds, diurnal and annual parallax.

*Q.* What is diurnal parallax?

*A.* It is the apparent difference in the situation of a heavenly body when seen in the zenith and horizon of two places at the same time. (See parallax of Mars and Moon.)

*Q.* What is annual parallax?

*A.* It is the apparent difference in the situation of a star as seen from the earth in opposite points of its orbit.

*Q.* Have the stars been observed to have any sensible parallax?

*A.* A few have been observed to have a small parallax of a part of a second. (NOTE.—No parallax has been discovered in more than 30 or 40 of them.)

*Q.* What is the cause of their having no appreciable parallax?

*A.* Because they are at such an immense distance from us.

*Q.* If the earth's orbit were a solid ring, how large would it appear when viewed from the nearest fixed star?

*A.* No larger than a lady's finger ring.

## LESSON XLVIII.

### LIGHT AND HEAT.

*Q.* What bodies produce light?

*A.* Luminous bodies.

*Q.* Is light a substance thrown off from a luminous body, or is it caused by a vibratory motion?

*A.* It is probably caused by the undulations of an extremely subtle fluid.

*Q.* In what direction are the rays of light thrown off from a luminous body?

*A.* In straight lines, and in all directions.

*Q.* With what velocity does light move?

*A.* About 192 thousand miles a second. (192,500.)

*Q.* How was this amazing velocity ascertained?

*A.* By observing the eclipses of Jupiter's moons.

*Q.* In what proportion do the light and heat of the planets increase or decrease?

*A.* In inverse proportion to the squares of their distances from the sun.

*Q.* Which planet has the most light and heat, and which the least?

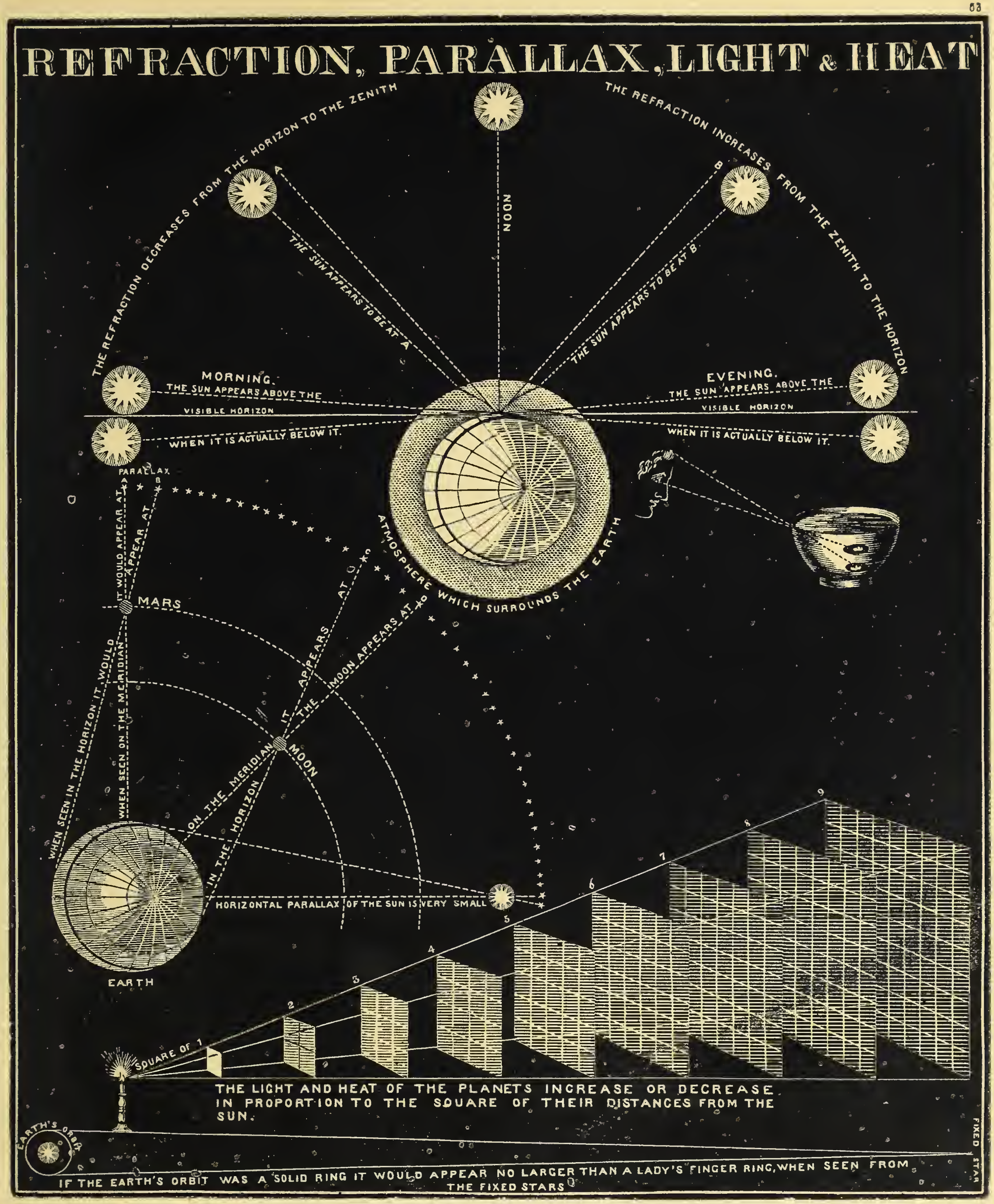
*A.* Mercury has the most, and Leverrier the least.

*Q.* If a board a foot square be placed one foot from a lighted candle, how many feet square would the shadow be upon the wall, nine feet from the candle?

*A.* Nine feet square, or eighty-one square feet.

*Q.* What amount of light and heat would fall upon the one foot and upon the 81 feet?

*A.* The same amount of light and heat would fall upon each.


REFRACTION, PARALLAX, LIGHT & HEAT
THE REFRACTION DECREASES FROM THE HORIZON TO THE ZENITH
THE REFRACTION INCREASES FROM THE ZENITH TO THE HORIZON
NOON
A
B
THE SUN APPEARS TO BE AT A
THE SUN APPEARS TO BE AT B
MORNING.
THE SUN APPEARS ABOVE THE
VISIBLE HORIZON
WHEN IT IS ACTUALLY BELOW IT.
EVENING.
THE SUN APPEARS ABOVE THE
VISIBLE HORIZON
WHEN IT IS ACTUALLY BELOW IT.
ATMOSPHERE WHICH SURROUNDS THE EARTH
PARALLAX
IT WOULD APPEAR AT
APPEAR AT
MARS
WHEN SEEN IN THE HORIZON IT WOULD
WHEN SEEN ON THE MERIDIAN
THE MOON APPEARS AT
IT APPEARS AT
MOON
ON THE MERIDIAN
IN THE HORIZON
HORIZONTAL PARALLAX OF THE SUN IS VERY SMALL
EARTH
SQUARE OF 1
1
2
3
4
5
6
7
8
9
THE LIGHT AND HEAT OF THE PLANETS INCREASE OR DECREASE IN PROPORTION TO THE SQUARE OF THEIR DISTANCES FROM THE SUN.
EARTH'S ORBIT
FIXED STAR
IF THE EARTH'S ORBIT WAS A SOLID RING IT WOULD APPEAR NO LARGER THAN A LADY'S FINGER RING, WHEN SEEN FROM THE FIXED STARS

## LESSON XLIX.

### TERRESTRIAL AND CELESTIAL GLOBES.

*Question.* What is a globe?

*Answer.* A globe is a round body or sphere.

*Q.* How many kinds of globes are there used in astronomy?

*A.* Two; terrestrial and celestial globes.

*Q.* What does the terrestrial globe represent?

*A.* It represents the earth.

*Q.* What are drawn upon the surface of the terrestrial globe?

*A.* Continents, islands, mountains, oceans, seas, rivers, republics, kingdoms, empires, &c.

*Q.* What does the celestial globe represent?

*A.* It represents the heavens as seen from the earth.

*Q.* What are usually drawn on the celestial globe?

*A.* The constellations or stars, galaxy or milky way, and the figures of various animals and objects from which the constellations are named.

*Q.* What is a constellation?

*A.* It is a group of stars, to which is applied the name of some animal or object.

*Q.* What is the number of constellations?

*A.* Ninety-three.

*Q.* In viewing the terrestrial globe, where is the observer supposed to be placed?

*A.* On its surface.

*Q.* In viewing the celestial globe, where must the observer suppose himself to be placed?

*A.* In the centre, looking towards the heavens. (Inside looking out.)

*Q.* What is the galaxy or milky way?

*A.* It is a luminous belt forming a complete circle in the heavens.

*Q.* Of what is the galaxy or milky way composed?

*A.* It is a vast number of stars, so far distant from us, and situated so nearly in the same direction, as to appear like a thin cloud.

*Q.* What is the position of the milky way in the heavens?

*A.* It extends from northeast to southwest through the whole circumference of the heavens.

*Q.* What are the celestial poles, or poles of the heavens?

*A.* They are the points where the earth's axis, if extended, would meet the heavens.

## LESSON L.

*Question.* What does the plane of the equator form, when extended to the heavens?

*Answer.* The equinoctial or celestial equator.

*Q.* At what angle do the ecliptic and equinoctial intersect each other?

*A.* At an angle of $23\frac{1}{2}$ degrees. (23° 28′)

*Q.* What does the plane of a meridian form when extended to the heavens?

*A.* A celestial meridian or circle of declination.

*Q.* What are measured on celestial meridians?

*A.* Declination and polar distance.

*Q.* What is the declination of a heavenly body?

*A.* It is its distance from the equinoctial, north or south.

*Q.* To what are the declination and polar distance always equal?

*A.* They are equal to 90 degrees, or a quarter of a circle.

*Q.* What is the right ascension of a heavenly body?

*A.* It is its distance east of the first point of Aries measured on the equinoctial.

*Q.* What angle expresses the right ascension?

*A.* The angle between the meridian passing through the body, and the one passing through the first point of Aries.

*Q.* How far is right ascension reckoned?

*A.* 360 degrees, or quite round the heavens.

*Q.* What are circles of latitude on the celestial globe?

*A.* They are great circles which pass through the poles of the ecliptic, and cut its plane at right angles.

*Q.* What is the latitude of a heavenly body?

*A.* It is its distance north or south of the ecliptic, measured on a circle of celestial latitude.

*Q.* What is the longitude of a heavenly body?

*A.* It is its distance east of the first point of Aries, measured on the ecliptic.

*Q.* What angle expresses the longitude?

*A.* The angle between the circle of latitude passing through the body, and the one passing through the first point of Aries.

*Q.* Where is this angle formed?

*A.* At the poles of the ecliptic, where the circles of latitude intersect each other.

*Q.* How far is celestial longitude reckoned?

*A.* It is reckoned 360 degrees.

## LESSON LI.

*Question.* What is a vertical circle?

*Answer.* It is a great circle in the heavens, passing through the zenith and nadir, and cutting the horizon at right angles.

*Q.* What vertical circle is the meridian?

*A.* It is that vertical circle which passes through the north and south points of the horizon.

*Q.* Which is the prime vertical?

*A.* The vertical circle which passes through the east and west points of the horizon.

*Q.* What are measured on the vertical circles?

*A.* Altitude and zenith distance.

*Q.* What is the zenith distance of a heavenly body?

*A.* It is its distance from the zenith.

*Q.* To what are the altitude and zenith distance always equal?

*A.* They are equal to 90 degrees.

*Q.* What is the azimuth of a heavenly body?

*A.* It is its distance east or west of the meridian.

*Q.* What angle expresses the azimuth?

*A.* The angle between the meridian and the vertical circle passing through the body.

*Q.* What is the amplitude of a heavenly body?

*A.* It is its distance north or south of the prime vertical.

*Q.* What angle expresses the amplitude?

*A.* The angle between the prime vertical, and the vertical circle passing through the body.

*Q.* Where are the angles expressing azimuth and amplitude formed?

*A.* At the zenith where the vertical circles intersect each other.

*Q.* On what circle are these angles measured?

*A.* On the horizon.

*Q.* To what are azimuth and amplitude always equal?

*A.* They are equal to 90 degrees.

[The diagram can be used to illustrate azimuth, amplitude, altitude, and zenith distance, by supposing the ecliptic to represent the celestial horizon, and the circles of celestial latitude to represent vertical circles.]


TERRESTRIAL & CELESTIAL GLOBES.
CELESTIAL GLOBE
NORTH STAR
NORTH POLE OF THE HEAVENS
CIRCLES OF CELESTIAL LATITUDE
VIEWING THE CELESTIAL GLOBE
TERRESTRIAL GLOBE
MILKY WAY
OR
GALAXY
ECLIPTIC
EQUINOCTIAL
SOUTH POLE OF THE HEAVENS

## LESSON LII.

### THE FIXED STARS.

*Question.* What are those stars called which always appear to be in the same situation with respect to each other?

*Answer.* They are called the fixed stars.

*Q.* What are the fixed stars supposed to be?

*A.* They are supposed to be suns like our own, with planets revolving around them.

*Q.* Are the stars luminous or opake bodies?

*A.* They are luminous bodies. (Astronomers have no doubt on this point.)

*Q.* Are all the stars of the same magnitude as the sun?

*A.* They are not; some are larger, and others no doubt smaller than the sun. (Note 1.)

[ "From the orbital motion of the double star 61 Cygni, compared with its distance, Bessel has concluded that the conjoint mass of its two individuals is 'neither much more nor much less than half the mass of our sun.' From the photometric experiments of Wollaston, on α (Alpha) Lyræ, compared with what we know of its distance, its actual emission of light may be gathered to be not less than 5½ times that of the sun. Sirius, which is nine times as bright as α Lyræ, and whose parallax is insensible, cannot, therefore, be estimated at less than 100 suns." *Edinburgh Review.*]

*Q.* What is the distance of the nearest fixed star, α (Alpha) Centauri?

*A.* It is so far distant that a cannon ball going 500 miles an hour, would take four millions of years to reach it.

Q. What is the number of stars whose distance is imperfectly known to us?

*A.* About 35; seven of which have their distances determined with considerable certainty.

*Q.* Do all the stars remain of the same brilliancy?

*A.* They do not; some exhibit a periodical change in their light.

*Q.* What is supposed to be the cause of this change in their light?

*A.* The revolution on their axes is supposed to present, alternately to us, sides of different brightness.

*Q.* What are those stars called which appear to be surrounded by a thin atmosphere?

*A.* Nebulous stars.

*Q.* Do stars ever disappear, or new ones become visible?

*A.* Thirteen stars have disappeared, and ten new ones become visible, during the last century. (Note 2.)

*Q.* What is supposed to be the cause of their disappearance?

*A.* They have probably ceased to be luminous.

*Q.* How do astronomers account for the appearance of new stars?

*A.* Opake bodies may have become luminous, or new suns may have been created.

## LESSON LIII.

*Question.* What do the milky way and the single stars that are visible to the naked eye, including our sun, constitute?

*Answer.* They constitute an immense cluster, or firmament, entirely distinct from the other clusters or nebulæ of the heavens. (Fig. 1.)

*Q.* What is the shape of this great cluster or firmament?

*A.* It has the form of a wheel or burning-glass.

[The stars extend much farther in the direction of the plane of the milky way, than they do at right angles to it. See Diagram.]

*Q.* What is the number of stars in our cluster?

*A.* They have been variously estimated from 10 to 100 millions.

*Q.* By what term do some astronomers designate our cluster or firmament?

*A.* They call it the universe. (Note 3.)

*Q.* Do the fixed stars have any apparent motion?

*A.* They do, but it is so slight as not to be easily detected.

*Q.* Around what, are all the stars in our cluster, including the sun, supposed to revolve?

*A.* Around the common centre of gravity of the cluster. [Fig. 1.)

*Q.* What group of stars is thought to be near the centre of the cluster?

*A.* The Pleiades, or seven stars. (Dr. Maedler.)

*Q.* In what part of the cluster is the solar system situated?

*A.* It is comparatively near the centre.

*Q.* How far from us is the centre of the cluster supposed to be?

*A.* About 150 times the distance of the nearest fixed star.

[Light is about 8 minutes in coming from the sun; about 3½ years in coming from the nearest fixed star, α Centauri; about 500 years in coming from the supposed centre of the cluster; and about 5,000 years in coming from the most remote stars in the cluster.]

*Q.* How long will it take the sun to revolve around this centre of gravity?

*A.* About twelve millions of years.

*Q.* What other motion have some of the stars, besides around the centre of the cluster?

*A.* Multiple stars, consisting of two or more, revolve likewise around their common centre of gravity.

*Q.* What is the number of these multiple stars?

*A.* About 6,000 have been observed.

*Q.* Do these stars appear double to the naked eye?

*A.* They do not; the most, require a good telescope to separate them.

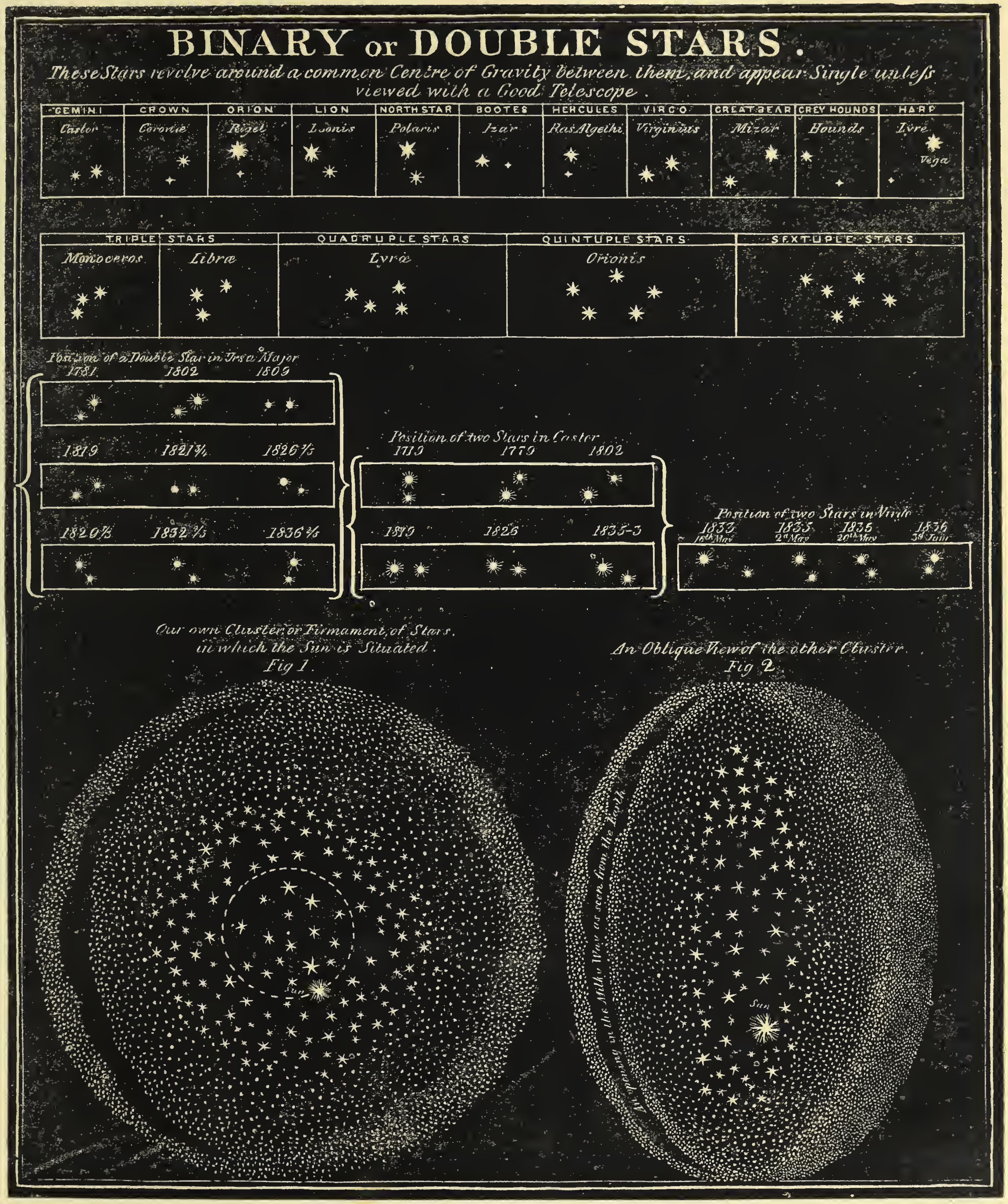
*Q.* When multiple stars consist of but two, what are they usually called?

*A.* Double stars, or binary systems.

Note 1.—Astronomers, until recently, considered all the stars to be of about the same magnitude, and probably as large as the sun; and that the stars of the first magnitude owed their brilliancy to their being nearer to us; but it has been found that the brightest star (Sirius) in the whole heavens, and which was considered to be the nearest fixed star, is at a much greater distance than some of the smaller stars. This clearly demonstrates that they are of very unequal magnitude.

Note 2.—There are now seven or eight well-attested cases of fixed stars suddenly glowing for a time with such brilliancy as to be visible in the day time, through the intensity of their light; then gradually fading away, and becoming entirely extinct. Laplace thinks that some great conflagrations, produced by extraordinary causes, have taken place on their surface.

Note 3.—The term universe, was until recently used to denote the whole creation of God, and was never used in the plural number: but astronomers use the term to denote an immense firmament or cluster of stars, entirely distinct from other clusters—of which there are many thousands visible with the telescope—and are at an immense distance from each other. Hence in speaking of these clusters, they call them universes.—[Prof. Mitchell.]


BINARY or DOUBLE STARS.
These Stars revolve around a common Centre of Gravity between them, and appear Single unless viewed with a Good Telescope.
GEMINI
Castor
CROWN
Coronæ
ORION
Rigel
LION
Leonis
NORTH STAR
Polaris
BOOTES
Izar
HERCULES
Ras Algethi
VIRGO
Virginius
GREAT BEAR
Mizar
GREY HOUNDS
Hounds
HARP
Lyre
Vega
TRIPLE STARS
Monoceros
Libræ
QUADRUPLE STARS
Lyræ
QUINTUPLE STARS
Orionis
SEXTUPLE STARS
Position of a Double Star in Ursa Major
1781
1802
1809
1819
1821¾
1826⅓
1829⅓
1832⅓
1836⅓
Position of two Stars in Castor
1719
1779
1802
1819
1826
1835-3
Position of two Stars in Virgo
1833 16th May
1835 2d May
1835 20th May
1836 3d June
Our own Cluster or Firmament of Stars, in which the Sun is Situated.
Fig 1.
Sun
An Oblique View of the other Cluster.
Fig 2.
Sun

## LESSON LIV.

### NEBULÆ.

*Question.* WHAT appearance has a nebula?

*Answer.* A nebula appears like a spot of pale light seen in the heavens.

*Q.* Of what are the nebulæ composed?

*A.* The most of them are great clusters of stars, so far distant as to appear like a thin cloud.

*Q.* Are there many of them?

*A.* About 6,000 have been discovered. (NOTE.—Their number is probably much greater; perhaps infinite.)

*Q.* What is the distance to these nebulæ?

*A.* Some of them are said to be so far distant, that light, traveling 192 thousand miles a second, would not reach us in less than 30 millions of years. [PROF. MITCHELL.]

*Q.* Are they visible to the naked eye?

*A.* Only a few are seen without a telescope.

*Q.* How large do they appear when viewed with a telescope?

*A.* Some of them appear as large as one tenth of the disc of the moon.

*Q.* Are these nebulæ seen in all parts of the heavens?

*A.* They are, although they are more numerous in a narrow zone, circumscribing the heavens, at right angles to the milky way.

*Q.* Into how many classes may nebulæ be divided?

*A.* Into five classes, viz., resolved nebulæ, resolvable nebulæ, stellar nebulæ, irresolvable and planetary nebulæ.

*Q.* What are resolved nebulæ?

*A.* They are those which have been discovered with the telescope to be great clusters of stars.

*Q.* What are resolvable nebulæ?

*A.* They are those which are considered to be composed of stars, but are so far distant that the telescopes have not as yet resolved them.

*Q.* What are stellar nebulæ?

*A.* They are those of an oval or round shape, increasing in density towards the centre. (NOTE.—They sometimes present the appearance of having a dim star in the centre.)

*Q.* What are irresolvable nebulæ?

*A.* They are those which are considered to be luminous matter in an atmospheric state, condensing into solid bodies like the sun and planets.

*Q.* What are the planetary nebulæ?

*A.* They are those which resemble the disc of a planet, and are considered to be in an uncondensed state.

*Q.* Are all nebulæ beyond our cluster?

*A* They are, except the milky way, and nebulous stars.

*Q.* By what general term do astronomers designate each nebula or cluster?

*A.* They call each nebula a UNIVERSE, or FIRMAMENT.

*Q.* What can you say of the great nebula in the Greyhounds?

*A.* It resembles our own cluster, or firmament of stars.

*Q.* What can you say of the great nebula in ORION?

*A.* This nebula was considered to be luminous matter in an uncondensed state, but it has lately been discovered to be stars by Lord Rosse, with his powerful telescope. (NOTE.—This nebula is visible to the naked eye.)

*Q.* What is the probable cause of many of the nebulæ appearing elliptical or elongated? (SEE DIAGRAM.)

*A.* It is probably caused by the edge of the nebula being turned more or less towards us.

### ORIGIN OF THE SOLAR SYSTEM.

MANY theories have been propounded at different periods of the history of Astronomy, respecting the original formation of our Solar System, as well as all other suns and systems, which it has pleased the GREAT CREATOR OF ALL THINGS to call into existence, but no one has gained so great favor or excited so violent opposition, as the theory first proposed by Sir William Herschel, and afterwards more especially applied by the celebrated La Place to the formation of the solar system.

This theory may be thus stated:—In the beginning all the matter composing the sun, planets and satellites, was diffused through space, in a state of exceedingly minute division, the ultimate particles being held asunder by the repulsion of heat. In process of time, under the action of gravitation, the mass assumed a round or globular shape, and the particles tending to the centre of gravity, a motion of rotation on an axis would commence. The great mass, now gradually cooling and condensing must increase its rotary motion, thereby increasing the centrifugal force at the equator of the revolving mass, until, finally, a ring of matter is actually detached from the equator, and is left revolving in space by the shrinking away from it, of the interior mass. If now we follow this isolated ring of matter, we find every reason to believe that its particles will gradually coalesce into a globular form, and in turn form satellites, as it was itself formed. It is unnecessary to pursue the reasoning further, for the same laws which produce one planet from the equator of the central revolving mass, may produce many—until finally, the process is ended by a partial solidification of the central mass, so great, that gravity aided by the attraction of cohesion, is more than sufficient to resist the action of the centrifugal force, and no further change occurs.

It has been urged in favor of this theory, that it accounts for the striking peculiarities which are found in the organization of the solar system. That the rings of Saturn are positive proofs of the truth of the theory, they having cooled and condensed without breaking. That the individuals constituting a system thus produced, must revolve and rotate as do the planets and satellites, and in orbits of the precise figure and position, as those occupied by the planets. It accounts for the rotation of the sun on its axis, and presents a solution of the strange appearance connected with the sun called the Zodiacal Light. It goes further and accounts for the formation of single, double, and multiple suns and stars—and by the remains of chaotic matter in the interstices between the stars, and which are finally drawn to some particular sun, whose influence in the end preponderates, accounts for the comets which enter our system from every region in space.

In support of this theory it has been urged that the comets, in their organization, present us with specimens of this finely divided nebulous or chaotic matter—and that the telescope reveals cloudy patches of light of indefinite extent, scattered throughout space, which give evidence of being yet unformed and chaotic. That many stars are found in which the bright nucleus or centre is surrounded by a halo or haze of nebulous light, and that round nebulous bodies are seen with the telescope, of an extent vastly greater than would fill the entire space encircled by the enormous orbit of the planet La Verrier, or having a diameter greater than 7000 millions of miles.

Such are a few of the arguments in support of this most extraordinary theory. We now present the objections which have been most strongly insisted on. The retrograde motions of the satellites of Herschel, and their great Inclination to the plane of the ecliptic cannot be accounted for by this theory. That computation shows that an atmosphere of uncondensed nebulous matter can extend to so great a distance from the sun, as does the matter composing the Zodiacal Light, and, finally, that the nebulous matter in the heavens will ultimately be resolved into immense congeries and clusters of stars, whose great distance has hitherto defied the power of the best instruments.

In reply to the first objection, the friends of the theory doubt the facts with reference to the satellites of Herschel. They reply that the matter composing the Zodiacal Light, being in the nature of cometary matter, is thrown to a greater distance from the sun than gravity would warrant, by that power residing in the sun which is able on the approach of comets to project those enormous trains of light, which sometimes render them so wonderful. As to the last objection, it is urged that although many nebulæ will doubtless be resolved into stars, by using more powerful telescopes, yet that these same telescopes will reveal more new nebulæ which cannot be resolved, than they will resolve—and as to the existence of nebulous matter, it is perfectly demonstrated by the physical organization of comets, and the existence of nebulous stars.

Such was the state of the Astronomical argument, when Lord Rosse's Great Reflector was first applied to the exploration of the distant regions of space. In a religious point of view, this theory had excited no small amount of discussion, in consequence of its supposed Atheistical tendencies. The friends of the theory contend that it was no more Atheistical to admit the formation of the universe by law, than to acknowledge that it is now sustained by laws. Indeed since we must go to the first great cause for matter in its chaotic state, as well as for the laws which govern matter, that this theory gave to us a grander view of the omniscience and omnipotence of God than could be obtained from any other source. In fine that it harmonized with the declaration of scripture, which tells us that "In the beginning God created the heavens and the earth, and the earth was *without form and void.*" If the earth came into existence in its present condition, then it had *form* and was *not void.* Hence, this first grand declaration of the inspired writer must refer to the formation of the matter, of which the heavens and earth were afterwards formed. Some went so far as to trace out dimly a full account of this theory in the order of creation, as laid down in Genesis.

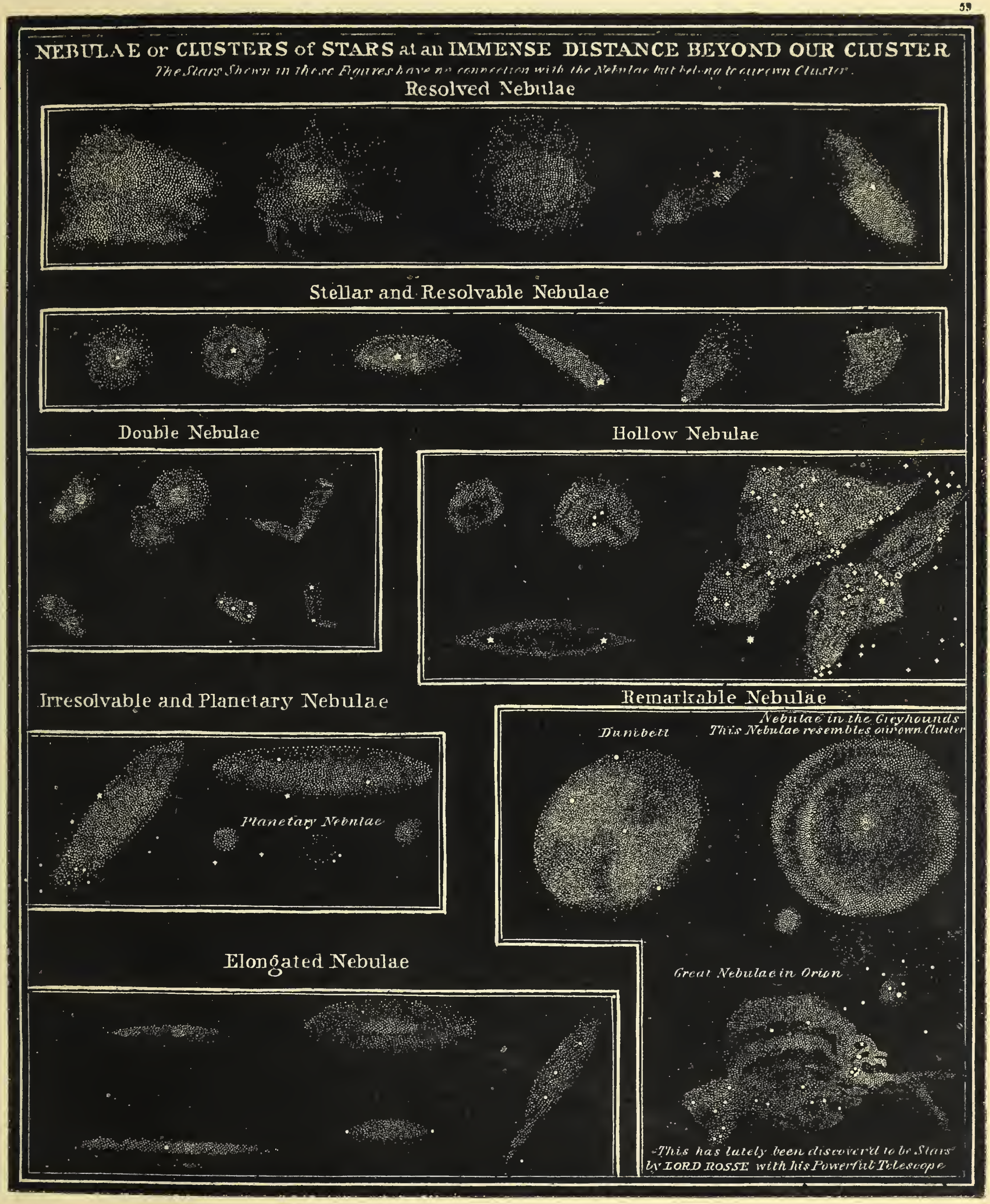
Let us now proceed to the discoveries of Lord Rosse, and their influence on this greatly disputed theory. The space penetrating power of his six feet reflector is much greater than that of Sir William Herschel's great telescope, and it was anticipated that many nebulæ which were unresolved into clusters of stars by Herschel, would yield under the greater power and light of Lord Rosse's telescope. This has proved to be the fact. Very many nebulæ have been removed from their old places, and must hereafter figure among the clusters, while we are informed that many yet remain, even of the old nebulæ, which defy the power of the monster telescope.

The most remarkable object which has been resolved by Lord Rosse, is the great nebula in Orion, one of the most extraordinary objects in the heavens. (SEE DIAGRAM.) Its size is enormous, and its figure very extraordinary. In certain parts adjoining the nebula the heavens are *jet black*, either from contrast or by the vacuity of these regions. Two immense spurs of light are seen to project from the principal mass of the nebula, and to extend to a most extraordinary distance. This will be better understood, by remembering that at the distance at which this nebula is removed from us, the entire diameter of the earth's orbit, 190 millions of miles, is an invisible point, less than one second, while this nebula extends to many thousands of times this distance, and more probably to many millions of times.

Several stars have been found, and are visible on the nebula, but have hitherto been regarded as being between the eye of the observer and this remote object. Sir William Herschel was unable to resolve this mysterious body, and yet the nebula gave indications of being of the resolvable kind, by its irregular and curdled appearance under high powers. Several years since Dr. J. Lamont, of Munich, after a rigid scrutiny of this nebula with his great Refractor, pronounced a portion of it to be composed of minute *stellar points*, and predicted its final perfect resolution into stars by greater power. This prediction has been fully verified, for Lord Rosse's great Reflector has solved the mystery, and filled this extraordinary object with the "jewelry of stars."

But the question recurs, what have the defenders of the nebular theory lost, or its enemies gained by this interesting discovery? We are all liable to reach conclusions too hastily, and to join issue on false points. If the nebular theory depended for its existence upon the irresolvability of the nebula in Orion, then indeed has the theory been entirely exploded. But this is not the fact. No one has asserted that the great nebula in Orion was *nebulous matter*, and if it were not, then none existed. Such an issue would have been a false one, had it been made.

The theory has neither lost nor gained by the discoveries thus far made; what time may develope it is impossible to say. In case certain data can be obtained, which appear to be accessible, then indeed may we demonstrate its truth or falsehood, by mathematical investigation. Until then, the safer plan is neither to adopt nor reject, but investigate until absolute truth shall reward our long continued labor, and reveal the mystery of the organization of that stupendous system, of which our humble planet forms an insignificant part.


NEBULAE or CLUSTERS of STARS at an IMMENSE DISTANCE BEYOND OUR CLUSTER
The Stars Shewn in these Figures have no connection with the Nebulae but belong to our own Cluster.
Resolved Nebulae
Stellar and Resolvable Nebulae
Double Nebulae
Hollow Nebulae
Irresolvable and Planetary Nebulae
Planetary Nebulae
Remarkable Nebulae
Dumbell
Nebulae in the Greyhounds
This Nebulae resembles our own Cluster
Great Nebulae in Orion
This has lately been discover'd to be Stars by LORD ROSSE with his Powerful Telescope
Elongated Nebulae

# DESCRIPTION AND USE OF THE SIDEREAL MAPS.

These Maps have been drawn by the Author with great care, in order to insure perfect accuracy in their representations of the heavens at the times specified in the annexed tables. They have been constructed to show the sidereal hemisphere visible on the parallel of latitude and meridian of New York (City.) To insure the greatest amount of accuracy, the stereographic projection has been made use of, because of all projections that occasions the least possible disarrangement of the relative positions of the stars and the angles they form one with another. There is a difficulty in reducing a concave or globular surface to a plane without distortion taking place somewhere; and in the projection here adopted a little compression will be found, gradually increasing from the horizon to the centre of the map. The constellations near the zenith will be found to be somewhat smaller, and the stars nearer together, than when near the edge of the map or horizon. Several stars often appear in the heavens, so as to form a group, presenting the appearance of a triangle, a rhomboid, trapezium or parallelogram: these figures are more correctly preserved by this projection than by any other which might have been made use of. The centre of each map represents the zenith on the parallel of New York, or that point in the heavens directly over the observer's head at the time specified in the annexed tables. They will answer equally well for any place within the United States, by making an allowance for the situation of the place north or south of the parallel of New York. For instance, to an observer at Washington the zenith, as represented on the maps, would be about $3\frac{1}{2}°$ degrees to the north of his zenith; also, to an observer at New Orleans the zenith of the maps would be about 12° degrees to the north: at Quebec the zenith of the maps would be about 6° degrees to the south; but to all places in the New England, Middle, and Western States, the variation would be so small that it would hardly be perceptible, unless by accurate observation. As we go north or south our sidereal hemisphere is continually changing. If we go north new stars seem to emerge from the northern horizon, while those near the southern horizon disappear below it; and if we should continue our journey to the north pole, we should find the north star in the zenith, or directly over head, and that the stars visible to us did not rise nor set, but described circles around the north star every 24 hours; these circles increasing in diameter, according to the distance of the star from the north star. To a person thus situated, the equator would be in the horizon, and he would see none of the stars in the southern hemisphere. If there were inhabitants at the south pole they would be similarly situated with regard to the stars in the southern hemisphere; they would never see the stars on the north side of the equator or in the northern hemisphere, nor would the stars in the southern hemisphere ever set to them. To the inhabitants at the equator, the whole of the stars, from pole to pole, would rise and set perpendicularly to their horizon once in every 24 hours. As the equator has no latitude, so has its zenith no declination, because the celestial equator is directly over it on a line from east to west. If an observer moves towards either pole from the equator, for every degree of his progress his zenith will have just so many degrees of declination, and as many degrees can he see beyond the pole towards which he is advancing; and he will lose sight of the pole from which he is receding in the same proportion. For example, as the inhabitants of New York are situated near 41° degrees north of the equator, their zenith is elevated 41° degrees above the celestial equator; and it follows that the inhabitants on the parallel of New York can see all the stars within 49° degrees south of the equator—for 41° added to 49° makes 90°—the distance from the zenith to the horizon; also between the zenith of New York and the north pole, are 49° degrees; requiring 41° degrees beyond the pole to make up the complement of 90 degrees; consequently the stars 41° degrees beyond the north pole never set to the inhabitants living on the parallel of New York, but describe circles, or appear to revolve around the pole star every 24 hours.

## EXPLANATIONS, SHOWING THE MANNER OF USING THE MAPS.

The pupil should be particularly instructed in the manner of using these maps, or they will be inclined to use them in the same manner as they do the maps of a Geography or Atlas, which will confuse and confound them. In using a geographical map the pupil is instructed to face the north, and lay the map before him; then the top represents the north, the right hand east, &c.: but it will be observed, that if this mode be adopted with these maps, the right hand represents the west and the left hand the east. Each map is intended to represent the whole visible heavens at the time given for observation; hence, if we face the south, and hold the map up over the head, with the pole star directed towards the north star in the heavens, it will then represent nearly the condition of the heavens. In viewing the stars south of our zenith, face the south, and hold the map up in front of the eye; but in viewing the stars to the north of our zenith, face the north, turn the map bottom upwards, and hold it so that the pole star on the map shall correspond with the pole star in the heavens, then the stars on the map will indicate the positions of the stars in the heavens. In viewing the stars to the east, face the east, and hold the map up before the eye, with the top turned towards the north; the map will then indicate the correct positions of the stars: also, in viewing the stars to the west, face the west, and hold the map up before the eye, with the top turned towards the north. Great care should be taken when an observation is made, so as not to mistake the planets Venus, Mars, or Jupiter, for fixed stars.

## DIRECTIONS FOR FINDING THE NORTH STAR, AT ANY TIME.

Every pupil should be instructed in the manner of pointing out the North Star at any time of the night. If they are enabled to do this at any time, it will assist them in making other important observations, as well as being of use on many occasions which occur in the life of every man. Many persons have been lost in a prairie or other unfrequented places, when if they had been able to have told the points of the compass they could have extricated themselves from their lost situation. This may be done in a very easy manner. There is hardly a child of 10 years of age who cannot at any time of night point out the stars in the Great Bear which form what is called the Great Dipper. Now if an imaginary line be drawn through the two stars which form the front edge of the Dipper, from the bottom towards the top, and continued about 20° degrees, it will pass very near the North Star—so near that it cannot be mistaken, there being no other stars of that magnitude near it. It should be borne in mind that this rule holds good in whatever position the Dipper may be at the time.

# PRINCIPAL CONSTELLATIONS VISIBLE, FROM JANUARY 21 TO APRIL 17.

**Ursa Major, the Great Bear.**—The first seven stars in this constellation form what is called the Great Dipper. It is situated about 15 degrees north of the zenith, and a little to the east of north. It is exactly bottom upwards, with the handle towards the east. There are four stars which form the dipper, and three in the Tail of the Bear, which form the handle. These stars cannot fail to be recognized at a glance. Six of these stars are of the second and one of the third magnitude. The first two, $\alpha$, $\beta$., are called pointers, as a line drawn through them towards the horizon would pass very near the North Star, which is about 30 degrees from them towards the horizon.

**Ursa Minor, the Little Bear.**—The stars in this constellation form a figure called by some a Wagon, and by others the Little Dipper. It is north of the Great Dipper and east of the North Star, which is in the end of the handle. The North Star is at the end of the tail of the Little Bear.

**Taurus, the Bull.**—The star $\alpha$, or Aldebaran, is one of the first magnitude, and is in the right eye of the Bull; hence, it is sometimes called the Bull's Eye. This constellation is situated nearly west, and about 20 degrees above the horizon. The cluster of stars on the head of the Bull is called the Hyades. There is a small cluster of stars on the neck of the Bull, and north of the word Taurus on the map. It consists of seven stars, very near together. This group is called the Pleiades, or Seven Stars. Six of these stars only are visible to the naked eye.

**Orion.**—This is one of the most remarkable constellations in the heavens, and was familiarly known to the ancient writers, Job and Homer. It contains two stars of the first magnitude, Betelgeuse on the right shoulder, and Rigel on the left foot, of Orion. Half way between these two stars are three stars in the girdle, in a right line, forming Jacob's Staff, or the Three Kings, as they are sometimes called. There is a large nebula seen in this constellation, or rather through it, as the nebula is at an immense distance beyond the stars. According to fable Orion was a mighty hunter, who accompanied Diana and Latona in the chase.

**Gemini, the Twins.**—The two principal stars in this constellation are ($\alpha$) Castor and ($\beta$) Pollux; one in the head of each Twin.

**Canis Minor, the Little Dog.**—This constellation contains two large stars, ($\alpha$) or Procyon, of the first, and ($\beta$) Mirza, of the third magnitude, besides several small stars. This constellation was said to be one of the hounds of Orion.

**Canis Major, the Great Dog.**—This constellation is to the southeast of Orion, and contains the star Sirius, the brightest star in the whole heavens. This is said by the Greeks to be one of Orion's hounds—but the Egyptians, no doubt, gave it the name of dog, from the fact that it gave them warning of the approach of the inundation of the waters of the Nile. When this star was seen in the direction of the source of the Nile they moved back from the river upon the high ground—and as the dog was ever watchful to announce the approach of danger, they gave the same name to this star, which they fancied warned them, although silently, of approaching danger.

**Leo Major, the Great Lion.**—The principal star in this constellation is ($\alpha$) or Regulus: it is on the meridian at the time for observation, and about 30 degrees south of the zenith. There are several bright stars in this constellation. The stars in the head and neck form a curve somewhat like a sickle, Regulus being in the end of the handle. This Lion was supposed to be a metamorphosis of the Nemæan Lion, which was slain by Hercules.

**Bootes, the Herdsman.**—This is a very large constellation, southeast of the Great Bear. The principal stars are ($\alpha$) Arcturus, of the first magnitude, and ($\varepsilon$) Izar of the second magnitude. This star is situated in the Belt of Bootes. This constellation is of great antiquity; so much so that it is doubtful from whence it derived its name. Bootes is represented as walking, holding in his right hand a spear, and in his left the leading cords of the two dogs Asterion and Chara, which seem to be barking at the Great Bear.

**Virgo, the Virgin.**—This constellation is east of Leo. The principal star is ($\alpha$) Spica, of the first magnitude, in the ear of corn, which the Virgin holds in her left hand, and is the only bright star in this constellation. The position of this star has been determined with great exactness for the benefit of navigators. It is situated within the zone, in the heavens traversed by the moon. The moon's distance from the star is used for determining the longitude at sea. According to the ancient poets, this constellation represented the virgin Astræa, the goddess of Justice, who lived upon the earth during the golden age; but being offended at the wickedness of mankind, during the brazen and iron ages of the world, she returned to heaven, and was placed among the constellations of the zodiac, with a pair of scales (Libra,) in one hand and a sword in the other.

**Corvus, the Crow.**—This is a small constellation south of the virgin. It contains four bright stars, forming a trapezium or irregular square. The brightest of the two upper stars, on the left, is called Algorab, in the east wing of the crow. The crow, it was said, was once of the purest white, but was changed to black, its present color, as a punishment for tale bearing.

**Corona Borealis, the Northern Crown.**—This is a small constellation between the head of Bootes and Hercules. It may be distinguished by six principal stars, which form a circular figure, resembling a wreath or crown. This beautiful cluster of stars was said to be in commemoration of a crown presented by Bacchus to Ariadne. the daughter of Minos, second king of Crete.

**Draco, the Dragon.**—This constellation coils its fore part around the pole of the Ecliptic, and its tail around the Pole Star. In consequence of its various windings, perhaps it may be found difficult to be traced. According to fable. Draco, the offspring of Typhon, with a hundred heads and as many voices, was the guardian of the golden apples that grew in the garden of Hesperides. He was slain by Hercules, who obtained the apples, and presented them to Eurystheus.

**Canes Venatici, the Grey Hounds.**—This constellation contains only small stars. These two hounds, which Bootes leads with a small cord, are named Asterion and Chara.

**Coma Berenices—Berenices Hair.**—This is a small constellation between the Greyhounds, on the north, and the Virgin, on the south. It contains only small stars.

**Crater, the Cup.**—This cup is south of the Great Lion, and east of the Crow. It contains seven stars, so situated as in some degree to resemble the outline of a cup. According to fable, Jupiter sent the Crow with a cup to fetch water; but the bird being of a vagrant disposition, wasted his time, and returning without the water, told Apollo that the stream was guarded by a venomous serpent. To punish the Crow for this falsehood, Apollo placed him opposite the cup, and commanded the serpent never to allow him to drink.

**Hydra, the Water Serpent.**—This is a very long constellation, extending over 100 degrees from west to east. It may be known by four small stars south of the Crab, and nearly west of Regulus. This was supposed to be the Lernæan Hydra, which Hercules slew.

**Sextans, the Sextant.**—This constellation was formed by Hevelius of stars not included in the other adjacent constellations. It contains only small stars.

**Argo Navis, the Ship Argo.**—This constellation is in the southern horizon. The head of the ship may be known by a small cluster of stars about 15 degrees of the dog star Sirius. The greater part of this constellation is below the horizon. Some said this was the celebrated ship in which Jason and his companions went to Colchis, in quest of the golden fleece, which had fled from Greece. Others maintained that the ship Argo was no other than the Ark of Noah.

# MAP, FROM JANUARY 21 TO APRIL 17.

[☞ THE Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. By occasional observations with these Maps, the pupil will become familiar with all the Stars of the first magnitude as well as the principal Constellations. The great advantage these Maps have over all others, is, that they show the whole visible heavens at the time given for observations, and the exact positions of the Stars from the observer as well as from each other. FOR EXAMPLE:—On the 21st of January, at 1 o'clock 40 minutes in the morning, the Stars occupy the same positions in the heavens as laid down on the Map. The Star REGULUS, of the first magnitude, will be exactly on the meridian, and about 26° degrees south of the zenith; PROCYON, or the LITTLE DOG, about 35° degrees west of REGULUS; and SIRIUS, or the GREAT DOG, southwest of Procyon, and near the horizon. In this manner the pupil will be able to trace out the principal Stars and Constellations with facility. There are many Sectional Maps published, but they are all subject to this one great objection—which is, the great difficulty the pupil has in locating it. This objection is entirely obviated in these Maps.]

## STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

LEO, THE LION—(**Regulus**, THE PRINCIPAL STAR.)—This star is 26° south of the zenith, and on the meridian at the times specified in the Table for Map No. 1.

VIRGO, THE VIRGIN—(**Spica.**)—This star is southeast, and about 20° above the horizon.

BOOTES, THE HERDSMAN—(**Arcturus.**)—This star is situated nearly east, and about 40° from the horizon.

LYRA, THE HARP—(**Vega.**)—This star is nearly northeast, and near the horizon.

CYGNUS, THE SWAN—(**Deneb.**)—This star is about 22° east of north, and very near the horizon, and perhaps not visible unless the atmosphere is very clear, and the observer situated upon an eminence.

AURIGA, THE CHARIOTEER—(**Capella.**)—This star is nearly northwest, and about half way from the zenith to the horizon.

TAURUS, THE BULL—(**Aldebaran.**)—This star is in the eye of the Bull, and nearly west, and about 20° above the horizon.

ORION, ORION—(**Betelgeuse.**)—This star is in the right shoulder of ORION, a little south of west, and about 30° above the horizon

ORION, ORION—(**Rigel.**)—This star is in the left foot of ORION, southwest of Betelgeuse, and very near the horizon.

CAÑIS MINOR, LITTLE DOG—(**Procyon.**)—This star is situated southwest, about 45° degrees from the horizon.

CANIS MAJOR, GREAT DOG—(**Sirius.**)—This star is southwest of PROCYON, about 20° from the horizon. This is the brightest star in the heavens, and was considered the nearest; but late observations have demonstrated to the contrary.

## TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

| | | H. | M. | | | H. | M. | | | H. | M. | | | H. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JANUARY | 21 | 1 | 40 | FEBRUARY | 12 | 12 | 12 | MARCH.... | 6 | 10 | 44 | MARCH... | 28 | 9 | 16 |
| .... | 22 | 1 | 36 | .... | 13 | 12 | 8 | .... | 7 | 10 | 40 | .... | 29 | 9 | 12 |
| .... | 23 | 1 | 32 | .... | 14 | 12 | 4 | .... | 8 | 10 | 36 | .... | 30 | 9 | 8 |
| .... | 24 | 1 | 28 | .... | 15 | 12 | — | .... | 9 | 10 | 32 | .... | 31 | 9 | 4 |
| .... | 25 | 1 | 24 | .... | 16 | 11 | 56 | .... | 10 | 10 | 28 | APRIL...... | 1 | 9 | — |
| .... | 26 | 1 | 20 | .... | 17 | 11 | 52 | .... | 11 | 10 | 24 | .... | 2 | 8 | 56 |
| .... | 27 | 1 | 16 | .... | 18 | 11 | 48 | .... | 12 | 10 | 20 | .... | 3 | 8 | 52 |
| .... | 28 | 1 | 12 | .... | 19 | 11 | 44 | .... | 13 | 10 | 16 | .... | 4 | 8 | 48 |
| .... | 29 | 1 | 8 | .... | 20 | 11 | 40 | .... | 14 | 10 | 12 | .... | 5 | 8 | 44 |
| .... | 30 | 1 | 4 | .... | 21 | 11 | 36 | .... | 15 | 10 | 8 | .... | 6 | 8 | 40 |
| .... | 31 | 1 | — | .... | 22 | 11 | 32 | .... | 16 | 10 | 4 | .... | 7 | 8 | 36 |
| FEBRUARY | 1 | 12 | 56 | .... | 23 | 11 | 28 | .... | 17 | 10 | — | .... | 8 | 8 | 32 |
| .... | 2 | 12 | 52 | .... | 24 | 11 | 24 | .... | 18 | 9 | 56 | .... | 9 | 8 | 28 |
| .... | 3 | 12 | 48 | .... | 25 | 11 | 20 | .... | 19 | 9 | 52 | .... | 10 | 8 | 24 |
| .... | 4 | 12 | 44 | .... | 26 | 11 | 16 | .... | 20 | 9 | 48 | .... | 11 | 8 | 20 |
| .... | 5 | 12 | 40 | .... | 27 | 11 | 12 | .... | 21 | 9 | 44 | .... | 12 | 8 | 16 |
| .... | 6 | 12 | 36 | .... | 28 | 11 | 8 | .... | 22 | 9 | 40 | .... | 13 | 8 | 12 |
| .... | 7 | 12 | 32 | MARCH.... | 1 | 11 | 4 | .... | 23 | 9 | 36 | .... | 14 | 8 | 8 |
| .... | 8 | 12 | 28 | .... | 2 | 11 | — | .... | 24 | 9 | 32 | .... | 15 | 8 | 4 |
| .... | 9 | 12 | 24 | .... | 3 | 10 | 56 | .... | 25 | 9 | 28 | .... | 16 | 8 | — |
| .... | 10 | 12 | 20 | .... | 4 | 10 | 52 | .... | 26 | 9 | 24 | .... | 17 | 7 | 56 |
| .... | 11 | 12 | 16 | .... | 5 | 10 | 48 | .... | 27 | 9 | 20 | .................... | | | |


VISIBLE HEAVENS FROM JANUARY 21ST TO APRIL 17TH
LACERTA
CYGNUS
LYRA
CASSIOPEA
ANDROMADA
CEPHEUS
TRIANGULUM
HERCULES
DRACO
URSA MINOR
POLE STAR
CAMELOPARDALUS
PERSEUS
ARIES
TAURUS
SERPENS
CANES VENATICI
URSA MAJOR
AURIGO
LYNX
BOOTES
ZENITH
COMA BERENICES
GEMINI
ORION
ERIDANUS
LIBRA
EQUATOR
CANCER
CANIS MINOR
VIRGO
LEO
ECLIPTIC
MONOCEROS
LEPUS
SEXTANS
Milky Way
CORVUS
CRATER
ARGO NAVIS
CANIS MAJOR
HYDRA
STARS VISIBLE
Nº MAG
11 of the 1st
34 2nd
91 3rd
207 4th
535 5th

# AN EXPLANATION OF LEAP-YEAR.

It has been found by observations, that the earth revolves on its axis 365¼ times nearly, while it is making one complete revolution around the sun, or while the sun moves from either equinox to the same equinox again; consequently the solar year, upon which the seasons depend, contains nearly 365¼ days. It will be seen from this that the difference between a year of 365 days and the year as measured by the sun, amounts to one day in every four years; so that in 120 years of 365 days, the seasons would fall back one whole month, or 30 days, and the season for May would be in June, and the season for June would be in July, &c. In 720 years the longest days would be in the month of December: but in about 1450 years the season would fall back through the twelve months, and would again correspond to their present arrangement. In order to keep the seasons to the same months, and to make the solar and civil year correspond, one day more is included in the month of February, every fourth year. This would always keep the solar and civil year together, if the earth revolved upon its axis exactly 365¼ times while it was revolving around the sun, or during the solar year; but the earth revolves from one equinox to the same again in 365 days, 5 hours, 48 minutes, 49 seconds; which is 11 min. 11 sec. less than 365¼ days: consequently, in allowing one day in every four years is allowing 44 min. 44 sec. too much; and in 132 years it would amount to 24 h. 36 min. 6 sec., or more than one day: so that the longest day, which is now on the 21st of June, would, in 132 years, be on the 20th of June, or one day earlier, and in 264 years the longest day would be on the 19th of June, and so on.

This mode of reckoning time, by making every fourth year a leap-year, was adopted by the Council of Nice, in the year of our Lord 325, when the longest day in the year happened June 21st, and the vernal equinox March 21st. This mode of reckoning was continued from the year 325, to 1752, a period of 1427 years; when it was found that the longest day was on the 10th of June, and the vernal equinox on the 10th of March; the vernal equinox having fallen back 11 days towards the beginning of the year. To restore the equinoxes to the same days of the month in which they happened in the year 325, eleven days were ordered, by the British Government, and the United States, then British colonies, to be stricken out of the month of September, 1752, by calling the 3d day the 14th; and it was ordered that hereafter one leap-year in every 132 years, or 3 leap-years in 400 years, should be omitted: that is, that the years 1700, 1800, and 1900, which by the Old Style would have been leap-years, should be common years of 365 days. This method gives 97 leap-years in every 400 years. Thus 400 multiplied by 365, plus 97 days for the leap-years, gives 146,097 days. This divided by 400 years makes 365 days 5 h. 49 min. 12 sec.; making a difference from the true solar year of only 23 seconds a year; an error which amounts only to one day in 3,866 years.

This new arrangement is called the New Style.

This change was made to keep the equinoxes and solstices to the same days of the same months, and to keep the time of celebrating Easter, and the other feasts, fasts, and holydays of the Episcopal Church, to the same seasons of the year. The Russians and some other eastern nations continue the Old Style at the present day. The year 1800 was not a leap year by the New Style, but would have been by the Old Style: the difference between the styles is now 12 days.

## RULE FOR ASCERTAINING WHAT YEARS ARE LEAP-YEARS.

Divide the years by 4, and if there is no remainder it is Leap-Year; if there is 1 remainder, it is the 1st year after the leap-year; if there is 2 remainder, it is the 2d; if there is 3 remainder, it is the 3d year after leap-year. The even centuries are leap-years only when, by cutting off the two cyphers, you can divide the other two figures without a remainder. Thus 19(00 is not divisible by 4 without a remainder—consequently it is not a leap-year. The years 2,000, 2,400, 2,800, &c. are leap-years; and 2,100, 2,200, 2,300, 2,500, 2,600, and 2,700 are not leap-years.

# EQUATION OF TIME.

It is observed that time, as measured by the sun, differs from that shown by a clock that keeps true and equal time: the solar day, or time from the sun's leaving the meridian of any place till he leaves the same again, being sometimes less than 24 hours, and sometimes more; that is, if by a true clock, on any day, the sun leaves the meridian of any place at just 12 o'clock, it is either a few seconds *before* or a few seconds *after* 12, when he leaves that meridian the next time: it is a few more seconds, either *before* or *after* 12, when he leaves that meridian again; and so on, till in a few weeks it is several minutes *before* or *after* 12 by the clock when the sun leaves the meridian.

It is, in fact, the place, and the meridian of the place, that leaves the sun; but we say the sun leaves the meridian, because by the motion of the earth round its axis, the sun appears to move round the earth every day; and by the motion of the earth round the sun, the sun appears to move in the ecliptic round the earth once a year. The motion of the earth round its axis is always uniform and equal, never faster at one time than at another; this is the only perfectly uniform and equal motion known: and the mean or average time of its revolution from the sun to the sun again is 24 hours; that is, the *average* or *mean time* from the sun's leaving the meridian of any place, till he leaves the same again, is 24 hours; though, as before said, it is sometimes more and sometimes less.

The difference between the time of the sun's leaving the meridian, and 12 o'clock, by a true clock, is called The Equation of Time: at greatest it is 16 min. 15 sec.; this is on the last of October, and first of November. On the 14th of April, 15th of June, 31st of August, and 23d of December, this equation or difference is nothing, as then the sun and clock agree; and these are the only days in the year on which the sun and clock *do* agree.

The Equation depends on two causes;—viz. 1. The unequal motion of the sun in the ecliptic;—And, 2. The obliquity of the ecliptic to the equator.

It has already been shown that the sun, as well as the moon, moves much slower when in or near its apogee, than when in or near its perigee; and that its *true* place is never the same as its *mean* place, except in apogee and perigee. Now as the motion of the earth round its axis on the side next the sun, is in the same direction as the apparent motion of the sun in the ecliptic, it is plain that the slower the sun moves, the sooner will any place on the earth's surface move round from the sun to the sun again; or the shorter will be the solar day; because as the earth revolves round its axis, any place on the earth's surface will overtake the sun in less time when he advances through a less space, than when he moves through a larger.

The first equation depends upon the sun's distance from the perigee or perihelion, and is the difference between the *mean* and *true* place of the sun, changed into time. It is greatest when the sun is half way between the aphelion and perihelion, and nothing when it is in the aphelion or perihelion. The sun is faster than the clock while it is moving from the aphelion to the perihelion, and slower, while it is moving from the perihelion to the aphelion. This difference, between the sun and clock, when greatest, is 7 min. 42 sec.

The second equation, depending upon the obliquity of the ecliptic to the equator, at greatest, is 9 min. 53 sec.—(*Spofford's Astronomy, page* 29.)

# PRINCIPAL CONSTELLATIONS VISIBLE, FROM APRIL 18 TO JULY 21.

**Corona Borealis, the Northern Crown.**—This constellation is about 15 degrees southwest of the zenith. Six of the principal stars form a circular figure resembling a wreath or crown.

**Bootes, the Herdsman.**—This constellation is situated west of the Crown. The principal star is ARCTURUS.

**Hercules.**—This constellation is east of CORONA or the Crown, and extends from 12 to 50 degrees, north declination. It contains one hundred and nineteen stars—one of the 2d magnitude and one of the 3d in the right shoulder. These are called BETA and GAMMA. The left or east arm of Hercules grasps the three headed monster CERBERUS.

According to mythology, this constellation is intended to immortalize the name of Hercules, the Theban, so celebrated in antiquity for his heroic valor and invincible prowess. By command of Eurystheus, he achieved a number of enterprises, the most difficult and arduous ever known, called the TWELVE LABORS OF HERCULES.

1st. He subdued the Nemæan Lion in his den, and clothed himself in his skin.

2d. He slew the LERNÆAN HYDRA, with a hundred hissing heads, and dipped his arrows in the gall of the monster, to render their wounds incurable.

3d. He took alive the stag with golden horns and brazen feet, which was famous for its incredible swiftness, after pursuing it for twelve months, and presented it unhurt to Eurystheus.

4th. He took alive the Erimanthean Boar, and killed the Centaurs which opposed him.

5th. He cleansed the stables of Augias, where 3,000 oxen had been confined for many years.

6th. He killed the carnivorous birds which ravaged the country of Arcadia, and fed on human flesh.

7th. He took alive, and brought into Peloponnesus, the wild bull of Crete, which no mortal durst look upon.

8th. He obtained for Eurystheus the Mares of Diomedes, which lived on human flesh, after having given their owner to be first eaten by them.

9th. He obtained the girdle of the Queen of the Amazons, a formidable nation of warlike females.

10th. He killed the monster Geryon, king of Gades, and brought away his numerous flocks, which fed upon human flesh.

11th. He obtained the Golden Apples from the Garden of Hesperides, which were watched by a dragon.

12th. He finally brought up to the earth the three headed dog Cerberus, who guarded the entrance to the infernal regions.

**Lyra, the Harp.**—This is a small but beautiful constellation. It contains ($\alpha$) VEGA, one of the brightest stars in the northern hemisphere, and is situated directly east, and between 30 and 45 degrees from the zenith.

It is asserted that this is the celestial Lyre which Apollo or Mercury gave to Orpheus, and upon which he played with such a masterly hand, that even the most rapid rivers ceased to flow; the wild beasts of the forest forgot their wildness, and for the time being became tame, and the mountains came to listen to his song.

**Aquila, the Eagle.**—T s constellation may be easily found by three stars in a right line; ALTAIR, of the first magnitude, midway between the other two.

This constellation is supposed to have been Merops, a king of the Island of Cos, who was transformed into an Eagle, and placed among the constellations.

**Delphinus, the Dolphin.**—This is a beautiful little cluster of stars, and may be easily distinguished by four principal stars in the form of a diamond. The Dolphin was made a constellation for persuading the goddess Amphitrite, who had made a vow of perpetual celibacy, to become the wife of Neptune.

**Ophiuchus, the Serpent Bearer.**—This constellation is represented as a man with a long beard, holding in his clenched hands a prodigious Serpent, which is writhing in his grasp. This constellation occupies a large space, from 15° north to 25° south of the equator. The principal star is RAS ALHAGUE, of the second magnitude, situated in the head. The star on the foot just south of the ecliptic is RHO. According to mythology, OPHIUCHUS or ESCULAPIUS, as he was sometimes called, was the god of Medicine. He was the son of Apollo, but was killed by Jupiter with a thunderbolt, for restoring Hippolytus to life.

**Scorpio, the Scorpion.**—This is one of the constellations of the zodiac. It is a very beautiful group, as it contains one star of the first, two of the second, and eleven of the third magnitude. ($\alpha$) Antares, of the first magnitude, is situated in the heart of the SCORPION. It is a little east of the meridian, and about 20 degrees above the horizon. Orion, a celebrated giant, having impiously boasted that there was no animal on earth which he could not subdue, DIANA, whom he had offended, sent a Scorpion, which stung him to death.

**Serpens, the Serpent.**—This constellation is united with that of OPHIUCHUS, who holds the serpent in his grasp. It may be distinguished by several bright stars in and near the head

**Libra, the Scales.**—This constellation contains 4 stars of the 2d magnitude, by which it may be distinguished; two of them being about 10 degrees northwest of Antares in the Scorpion. About twenty-two hundred years ago this constellation coincided with the sign Libra of the ecliptic, and when the sun entered this constellation the days and nights were equal; hence it was very appropriately represented by the ancients by a pair of scales, which denote equality.

**Scutum, or Sobieski's Shield.**—This is a small constellation, instituted by HEVELIUS. It may be known by three small stars in the form of a triangle.

**Vulpecula et Anser**—(THE FOX AND GOOSE.)—This constellation was also established by HEVELIUS, and is situated south of he Swan and north of the Dolphin and Eagle. It contains only small stars.

# MAP, FROM APRIL 18 TO JULY 21.

[☞ THE Stars and Constellations upon this MAP will occupy the exact positions in the heavens as they are laid down on the MAP, at the times for observations, as specified in the table. The centre of the MAP represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. There will be eight stars of the first magnitude visible, the most conspicuous of which will be Arcturus, Vega, Altair, Deneb, Antares, and Spica. The other two being near the horizon, may not be visible unless the atmosphere is very clear.]

## STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

BOOTES, THE HERDSMAN—(**Arcturus** THE PRINCIPAL STAR.)—This star is situated towards the southwest, and about 30° from the zenith

VIRGO, THE VIRGIN—(**Spica.**)—This star is almost in a direct line southwest of Arcturus, and about 30° above the horizon.

LYRA, THE HARP—(**Vega.**)—This star is due east and about 37° from the zenith.

LEO MAJOR, THE GREAT LION—(**Regulus.**)—This star is due west, and about 10° above the horizon—perhaps not visible unless the atmosphere is very clear.

AQUILA, THE EAGLE—(**Altair.**)—This star is nearly southeast of Vega, and about half way from Vega to the horizon.

CYGNUS, THE SWAN—(**Deneb.**)—This star is nearly northeast of the zenith and east of the North Star.

AURIGA, THE CHARIOTEER—(**Capella.**)—This star is about 16° west of north, and very near the horizon ; perhaps not visible.

SCORPIO, THE SCORPION—(**Antares.**)—This star is nearly south, being only about 20° east of the meridian. It is about 30° above the southern horizon. There are two stars of the second magnitude about 10° to the northwest of it.

## TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

| | | H. | M. | | | H. | M. | | | H. | M. | | | H. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| APRIL..... | 18 | 2 | 16 | MAY...... | 12 | 12 | 40 | JUNE..... | 5 | 11 | 4 | JUNE... | 29 | 9 | 28 |
| .... | 19 | 2 | 12 | .... | 13 | 12 | 36 | .... | 6 | 11 | — | .... | 30 | 9 | 24 |
| .... | 20 | 2 | 8 | .... | 14 | 12 | 32 | .... | 7 | 10 | 56 | JULY..... | 1 | 9 | 20 |
| .... | 21 | 2 | 4 | .... | 15 | 12 | 28 | .... | 8 | 10 | 52 | .... | 2 | 9 | 16 |
| .... | 22 | 2 | — | .... | 16 | 12 | 24 | .... | 9 | 10 | 48 | .... | 3 | 9 | 12 |
| ... | 23 | 1 | 56 | .... | 17 | 12 | 20 | .... | 10 | 10 | 44 | .... | 4 | 9 | 8 |
| .... | 24 | 1 | 52 | .... | 18 | 12 | 16 | .... | 11 | 10 | 40 | .... | 5 | 9 | 4 |
| .... | 25 | 1 | 48 | .... | 19 | 12 | 12 | .... | 12 | 10 | 36 | .... | 6 | 9 | — |
| .... | 26 | 1 | 44 | .... | 20 | 12 | 8 | .... | 13 | 10 | 32 | .... | 7 | 8 | 56 |
| .... | 27 | 1 | 40 | .... | 21 | 12 | 4 | .... | 14 | 10 | 28 | .... | 8 | 8 | 52 |
| .... | 28 | 1 | 36 | .... | 22 | 12 | — | .... | 15 | 10 | 24 | .... | 9 | 8 | 48 |
| .... | 29 | 1 | 32 | .... | 23 | 11 | 56 | .... | 16 | 10 | 20 | .... | 10 | 8 | 44 |
| .... | 30 | 1 | 28 | .... | 24 | 11 | 52 | .... | 17 | 10 | 16 | .... | 11 | 8 | 40 |
| MAY........ | 1 | 1 | 24 | .... | 25 | 11 | 48 | .... | 18 | 10 | 12 | .... | 12 | 8 | 36 |
| .... | 2 | 1 | 20 | .... | 26 | 11 | 44 | .... | 19 | 10 | 8 | .... | 13 | 8 | 32 |
| .... | 3 | 1 | 16 | .... | 27 | 11 | 40 | .... | 20 | 10 | 4 | .... | 14 | 8 | 28 |
| .... | 4 | 1 | 12 | .... | 28 | 11 | 36 | .... | 21 | 10 | — | .... | 15 | 8 | 24 |
| .... | 5 | 1 | 8 | .... | 29 | 11 | 32 | .... | 22 | 9 | 56 | .... | 16 | 8 | 20 |
| .... | 6 | 1 | 4 | .... | 30 | 11 | 28 | .... | 23 | 9 | 52 | .... | 17 | 8 | 16 |
| .... | 7 | 1 | — | .... | 31 | 11 | 24 | .... | 24 | 9 | 48 | .... | 18 | 8 | 12 |
| .... | 8 | 12 | 56 | JUNE..... | 1 | 11 | 20 | .... | 25 | 9 | 44 | .... | 19 | 8 | 8 |
| .... | 9 | 12 | 52 | .... | 2 | 11 | 16 | .... | 26 | 9 | 40 | .... | 20 | 8 | 4 |
| .... | 10 | 12 | 48 | .... | 3 | 11 | 12 | .... | 27 | 9 | 36 | .... | 21 | 8 | — |
| .... | 11 | 12 | 44 | .... | 4 | 11 | 8 | .... | 28 | 9 | 32 | ..................... | | | |


VISIBLE HEAVENS FROM APRIL 18TH TO JULY 21ST
PERSEUS
AURIGA
GEMINI
CAMELOPARDALUS
LYNX
CANCER
CASSIOPEA
ANDROMEDA
PEGASUS
LACERTA
Milky Way
CEPHEUS
POLAR STAR
URSA MINOR
URSA MAJOR
LEO MINOR
LEO
DRACO
CYGNUS
VULPECULA
DELPHINUS
EQUULEUS
EQUATOR
AQUARIUS
LYRA
THE ZENITH
CANES VENATICI
COMA BERENICES
CORONA BOREALIS
HERCULES
BOOTES
AQUILA
CAPRICORNUS
SERPENS
VIRGO
CRATER
SCUTUM
OPHIUCHUS
LIBRA
ECLIPTIC
CORVUS
SAGITTARIUS
HYDRA
SCORPIUS
CENTAURUS
LUPUS
Constellations EAST Rising
Constellations WEST Setting
STARS VISIBLE
No. MAG
8 of the 1st
39 2nd
102 3rd
210 4th
511 5th

# TO FIND THE MAGNITUDES OF THE PLANETS.

The magnitudes of all globes or spheres, are in proportion to one another, as the *cubes* of their diameters;—hence, if we cube the diameters of any two globes, and divide the greater product by the less, the quotient will show how many times the one is greater than the other.

[Note.—The cube of any number is the number multiplied into itself, and that product multiplied by the first number.]

**Example.**—Suppose two globes, one of 5 feet, and the other 10 feet in diameter—

| | | |
|---|---|---|
| 5 | 10 | |
| 5 | 10 | |
| 25 | 100 | |
| 5 | 10 | |
| 125. cube of 5. | 1000 cube of 10. | Then 125 ÷ 1000 / 1000 = 8. |

Hence it will be seen that the globe of 10 feet in diameter, is 8 times the magnitude of the less.

To find the magnitudes of the planets, compared with that of the earth, observe the following Rule.—

Cube the diameter of the earth, which is 7,912 miles, and also the diameter of each planet,—then if the cube of the earth's diameter, is greater than that of the planet, divide the greater by the less, and the quotient will show how many times the earth is greater than the planet; but if the cube of the diameter of any planet, is greater than the cube of the earth's diameter, divide the cube of the planet's diameter by the cube of the earth's diameter, and the quotient will show how many times the planet is greater than the earth.

### EXAMPLE I.

Earth's Diameter, 7,912×7,912=62,599,744×7,912=495,289,174,528, cube of earth's diameter.

Mercury's Diameter, 3,200×3,200=10,240,000×3,200=32,768,000,000, cube of Mercury's diameter

Divide the greater by the less,—

32,768,000,000)495,289,174 528(15 times less than the earth.
32,768,000,000
―――――――
167,609.174.528
163,840,000,000
―――――――
3,769,174,528

### EXAMPLE II.

Diameter of the Sun—
886,952×886,952×886,952=697,750,814,394,833,408.

Divide by cube of earth's diameter—
495,289,174,528)697,750,814,394,833,408(=1,408,734.

| | Diameters. | | Cubes of their Diameters. | |
|---|---|---|---|---|
| Mercury, | 3,200 | miles | 32,768,000,000 | miles |
| Venus, | 7,700 | " | 456,533,000,000 | " |
| Earth, | 7,912 | " | 495,289,174,528 | " |
| Mars, | 4,189 | " | 73,507,403,269 | " |
| Vesta,* | 270 | " | 19,683,000 | " |
| Juno,* | 1.400 | " | 2,744.000,000 | " |
| Ceres,* | 1,600 | " | 4,096,000,000 | " |
| Pallas,* | 2,100 | " | 9.261,000,000 | " |
| Moon, | 2,180 | " | 10,360,232.000 | " |
| Jupiter, | 87,000 | " | 658,503,000,000,000 | " |
| Saturn, | 79,000 | " | 493,039,000,000,000 | " |
| Herschel, | 35,000 | " | 42,875,000,000,000 | " |
| Leverrier, | 35,000 | " | 42,875,000,000,000 | " |
| Sun, | 886,952 | " | 697,750,814,394,833,408 | " |

* Diameters of the other Asteroids are not known.

### EXAMPLE I.

| | Cube of earth's diameter, 495,289,174,528. | Of the earth's magnitude |
|---|---|---|
| 32,768.000,000 | | 15 Mercury, $\frac{1}{15}$ |
| 456,533,000,000 | | 9 Venus, $\frac{9}{10}$ |
| 73,507,403,269 | | 6.73 Mars, $\frac{1}{7}$ nearly, |
| 19.683,000 | | 25,163 Vesta, $\frac{1}{25000}$ |
| 2,744,000,000 | | 180. Juno, $\frac{1}{180}$ |
| 4,096,000,000 | | 120. Ceres, $\frac{1}{120}$ |
| 9,261,000.000 | | 53 Pallas, $\frac{1}{53}$ |
| 10,360,232,000 | | 58 Moon, $\frac{1}{45}$ nearly, |

### EXAMPLE II.

| Cube of Earth's Diameter 495,289,174,528. | |
|---|---|
| 658,503.000,000.000. | 1329+Jupiter larger than the earth. |
| 493.039.000.000,000. | 995+Saturn " " " |
| 42,875,000,000,000. | 86+Herschel " " " |
| 42.875,000,000,000. | 86+Leverrier," " " |
| 697,750,814,394,833,408. | 1,408.734. Sun " " " |

Note.—The teacher might require the more advanced pupils in the class to work out the above problems on their slates. It would be a profitable exercise for them in arithmetic, as well as fixing in the mind the magnitudes of the planets.

# TO FIND THE DISTANCES OF THE PLANETS FROM THE SUN.

The celebrated astronomer, Kepler, discovered that all the planets are subject to one general law, which is, that the "*squares of their periodic times are proportional to the cubes of their mean distances from the sun.*" This law was fully demonstrated and established by Sir Isaac Newton. Astronomers found it very easy to ascertain the periodic times of the planets, which only required them to observe the time it took each planet to revolve around the sun from any particular star to the same star again; but to find the distances of the planets from the sun, they found a much more difficult task. By observations made upon the transits of Venus, the earth's distance from the Sun, has been found to be about 95,000,000 of miles,—hence, if we have the periodic times of the planets, and the distance of one of them from the sun we can, by this law of Kepler's, find the distances of the other planets by the simple rule of proportion. Therefore, to find the distance of Mercury from the sun, we say, as the square of 365 days (which is 133,225) is to the cube of 95,000,000 of miles, (which is 857,375,000,000,000,000,000,000) so is the square of 88 days, (which is 7,744) to a fourth term, which is the cube of Mercury's distance from the sun. And if the cube root of this term be extracted, the answer will be 37,000,000 of miles, nearly.

THE FOLLOWING ARE THE STATEMENTS TO FIND THE DISTANCES OF THE OTHER PLANETS FROM THE SUN.

As 133,225 is to 857,375,000,000,000,000,000,000 So is the square of the periodic time, in days, of each planet separately to the fourth term, which will be the cube of the distance of the planet from the sun. Extract the cube root of the fourth term, so found, and it will give the planet's mean distance from the sun.

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........................................
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# PRINCIPAL CONSTELLATIONS VISIBLE, FROM JULY 22 TO OCTOBER 31.

**Cygnus, the Swan.**—This constellation is situated a little to the west of the zenith. It is represented with outspread wings, flying in the direction of the MILKY WAY to the southwest. The five principal stars are so arranged as to form a large and regular Cross. Deneb, a star of the first magnitude, is in the head of the Cross, and ALBIREO, situated in the beak of the Swan, forms the foot. Over the right wing of the Swan is a remarkable double star, known by the name of "61 Cygni." These stars are of the 5th and 6th magnitude; they revolve round a common centre of gravity between the two, in 540 years. These two stars will ever be memorable as being the first whose distance from us was measured with much precision, and are the nearest to us, with a single exception, of any as yet known. The star ($\alpha$) Centauri is about one-third the distance of 61 Cygni. Observations have been made on a great many others; but their parallax is much less, and in most cases is so small as not to be perceptible with the most accurate instruments. The distance of 61 Cygni was ascertained by BESSEL, from his observations, in the years 1837, 1838 and 1839. He found their distance 592,000 times the earth's mean distance from the sun. So great is this distance, that a CANNON BALL, moving 500 miles an hour, would not reach those two stars in less than thirteen millions of years. The sun, seen from these stars, would appear like a star of the 5th magnitude. Previous to this discovery the stars were considered to be about the same in magnitude, and the brightest stars to owe their brilliancy to their being nearer to us; but the brightest star in the whole heavens (Sirius, the great Dog Star,) is at a much greater distance than these, and owes its brilliancy to its superior magnitude or much greater brilliancy.

**Lyra, the Harp.**—This constellation is next to the SWAN. For a description of this constellation, see explanations to Map No. 2, from April 18 to July 31.

**Cepheus, the King.**—This constellation may be known by three stars of the third magnitude in a right line—in the neck, breast, and knee. He stands with his left foot over the pole. He holds a sceptre in his hand, extended towards Cassiopeia, his wife. CEPHEUS was the king of Ethiopia: the name of his queen was Cassiopeia. He was one of the ARGONAUTS who accompanied JASON in his expedition from Greece to Colchis, in quest of the Golden Fleece, and at his death was changed into a constellation.

**Cassiopeia, the Lady in her Chair.**—This constellation is situated east of CEPHEUS. She is represented in regal state, seated on a throne or chair, holding in her left hand the branch of a palm tree. She is surrounded by her royal family—CEPHEUS, her husband, on her right hand; PERSEUS, her son-in-law, on her left, and ANDROMEDA, her daughter, just above her. This constellation contains 55 stars, that are visible to the naked eye: five of these are of the 3d magnitude, which, with two smaller ones, form a figure resembling an inverted chair.

Cassiopeia was the wife of CEPHEUS, king of Ethiopia. She was possessed of great beauty, and boasted herself fairer than Juno, the sister of Jupiter, or the Nereides, a name given to the sea nymphs. This provoked the nymphs of the sea, who complained to Neptune, of the insult. He sent a frightful monster to punish her insolence. It was finally ordained that she should chain her daughter Andromeda, whom she tenderly loved, to a desert rock on the beach, and leave her exposed to the fury of this monster. She was thus left, and the monster approached; but as he was going to devour her, PERSEUS killed him.

**Andromeda.**—This constellation is south of CASSIOPEIA. It contains 66 stars, three of which are of the third magnitude, viz: Sirrah, in the head; Mirach, in the breast, and Almak, in the feet. They stand nearly in a straight line. ANDROMEDA, the daughter of Cepheus and Cassiopeia, was exposed to be devoured by a Sea Monster, to appease the wrath of Neptune. She was accordingly chained to a rock near JOPPA, (now Jaffa in Syria,) and at the moment the monster was going to devour her, Perseus, who was returning through the air from the conquest of the GORGONS, saw her and was captivated by her beauty. He promised to deliver her and destroy the monster, if her father would give her to him in marriage. Cepheus consented, and Perseus instantly changed the sea monster into a rock, by showing him Medusa's head, which was still reeking in his hand. This fable of Andromeda and the sea monster might mean that she was courted by some monster of a sea captain, who attempted to carry her away, but was prevented by another more gallant and successful rival.

**Pegasus, the Flying Horse.**—This constellation is represented with wings. It may be known by four stars, which form a regular quadrangle or trapezium. The northeastern of these four stars is in the head of ANDROMEDA. Their names are ($\alpha$) Markab, ($\beta$) Scheat, Algenib, and ($\alpha$) Sirrah, in the head of Andromeda. According to fable, Pegasus was a winged horse, which sprang from the blood of Medusa, when Perseus cut off her head.

**Equuleus, the Little Horse.**—This is a small cluster of stars west of the head of the Flying Horse. Only the head is visible. This is supposed to represent the horse which Mercury gave to Castor, and which he named CELERIS.

**Delphinus, the Dolphin.**—This is a beautiful little constellation, between the Eagle and Equuleus, or Little Horse. It may be distinguished by four stars in the shape of a diamond, with two small stars which form the tail. (See map No. 2, and explanation.)

**Sagittarius, the Archer.**—This is the tenth constellation in the zodiac. It is situated to the southwest, near the horizon. It may be known by five stars, forming a figure resembling a short handled dipper. It appears turned up, with the handle to the north, and the bowl towards the east. SAGITTARIUS, or Chiron, the son of SATURN, was a twofold being—half man and half horse. This constellation was intended, no doubt, by the ancients to represent the season for hunting; for when the sun enters this sign, the trees have cast their foliage, which enables the hunter to pursue his game to better advantage.

**Capricornus, the Goat.**—This is the next sign in the ecliptic, east of Sagittarius. There are two conspicuous stars in the head, called Giedi and Dabih. Giedi is the most northern star of the two, and is double. Several other stars may be traced out by reference to the map. The goat was observed by the ancients to be fond of climbing high mountains and lofty precipices, and was therefore considered emblematical of the sun, which, having in this sign reached his greatest southern declination, begins to re-ascend towards the north.

**Aquarius, the Water Bearer.**—This constellation is represented by the figure of a man pouring out water from an urn, and is north and east of Capricornus. It may easily be traced by reference to the map. The ancient Egyptians supposed the disappearing of Aquarius caused the waters of the Nile to rise by the sinking of his urn in the water.

**Pisces, the Fishes.**—This is the last sign in the zodiac. This constellation is represented by two fishes, a considerable distance apart, tied by a cord or riband. The stars in this constellation are of the 4th and inferior magnitudes. The probable origin of this sign was from the fact, that when the sun was in it, it was the season when fish were abundant, and easily taken.

**Piscis, the Southern Fish.**—This constellation is south of Aquarius, and is easily distinguished by the star Fomalhaut, of the first magnitude, with two small stars, which form an equilateral triangle. These three are the only important stars in this constellation. This constellation is supposed to have taken its name from the transformation of Venus into the shape of a fish, when she fled, terrified at the horrible advances of the monster Typhon, who was said to have an hundred heads.

**Ursa Major, the Great Bear.**—This constellation is directly north, and touches the horizon. The Dipper, which is a part of this constellation, is a little to the northwest of the north star, and is right side up, with the handle to the west. (For explanation, see map No. 1.)

**Lacerta, the Lizard.**—This is a small constellation near the zenith. It contains a few stars of inferior magnitude.

# MAP, FROM JULY 22 TO OCTOBER 31.

[☞ The Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. There will be only six stars of the first magnitude visible, the most conspicuous of which will be Deneb, Vega, Altair, and Capella. The other two, Aldebaran and Fomalhaut, being near the horizon, may not be visible unless the atmosphere is very clear.]

## STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

CYGNUS, The Swan—(**Deneb** the principal star.)—This star is situated directly west, and about 20° from the zenith. It is in the middle of the Milky-way.

LYRA, The Harp—(**Vega.**)—This star is about 20° west of Deneb.

AQUILA, The Eagle—(**Altair.**)—This star is situated towards the southwest, and about 35° from the zenith.

PISCIS, Southern Fish—(**Fomalhaut.**)—This star is about 10° east of south, and about 15° above the southern horizon—perhaps it will not be visible only when the atmosphere is clear.

TAURUS, The Bull—(**Aldebaran.**)—This star is nearly north-east, and within 10° of the horizon. It will not be visible only when the atmosphere is very clear.

AURIGA, The Charioteer—(**Capella.**)—This star is directly east of the North Star, and about midway to the horizon.

## TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

| | | H. | M. | | | H. | M. | | | H. | M. | | | H. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JULY...... | 22 | 1 | 56 | AUGUST... | 17 | 12 | 12 | SEPTEMBER | 12 | 10 | 28 | OCTOBER... | 8 | 8 | 44 |
| .... | 23 | 1 | 52 | .... | 18 | 12 | 8 | .... | 13 | 10 | 24 | .... | 9 | 8 | 40 |
| .... | 24 | 1 | 48 | .... | 19 | 12 | 4 | .... | 14 | 10 | 20 | .... | 10 | 8 | 36 |
| .... | 25 | 1 | 44 | .... | 20 | 12 | — | .... | 15 | 10 | 16 | .... | 11 | 8 | 32 |
| .... | 26 | 1 | 40 | .... | 21 | 11 | 56 | .... | 16 | 10 | 12 | .... | 12 | 8 | 28 |
| .... | 27 | 1 | 36 | .... | 22 | 11 | 52 | .... | 17 | 10 | 8 | .... | 13 | 8 | 24 |
| .... | 28 | 1 | 32 | .... | 23 | 11 | 48 | .... | 18 | 10 | 4 | .... | 14 | 8 | 20 |
| .... | 29 | 1 | 28 | .... | 24 | 11 | 44 | .... | 19 | 10 | — | .... | 15 | 8 | 16 |
| .... | 30 | 1 | 24 | .... | 25 | 11 | 40 | .... | 20 | 9 | 56 | .... | 16 | 8 | 12 |
| .... | 31 | 1 | 20 | .... | 26 | 11 | 36 | .... | 21 | 9 | 52 | .... | 17 | 8 | 8 |
| AUGUST... | 1 | 1 | 16 | .... | 27 | 11 | 32 | .... | 22 | 9 | 48 | .... | 18 | 8 | 4 |
| .... | 2 | 1 | 12 | .... | 28 | 11 | 28 | .... | 23 | 9 | 44 | .... | 19 | 8 | — |
| .... | 3 | 1 | 8 | .... | 29 | 11 | 24 | .... | 24 | 9 | 40 | .... | 20 | 7 | 56 |
| .... | 4 | 1 | 4 | .... | 30 | 11 | 20 | .... | 25 | 9 | 36 | .... | 21 | 7 | 52 |
| .... | 5 | 1 | — | .... | 31 | 11 | 16 | .... | 26 | 9 | 32 | .... | 22 | 7 | 48 |
| .... | 6 | 12 | 56 | SEPTEMBER | 1 | 11 | 12 | .... | 27 | 9 | 28 | .... | 23 | 7 | 44 |
| .... | 7 | 12 | 52 | .... | 2 | 11 | 8 | .... | 28 | 9 | 24 | .... | 24 | 7 | 40 |
| .... | 8 | 12 | 48 | .... | 3 | 11 | 4 | .... | 29 | 9 | 20 | .... | 25 | 7 | 36 |
| .... | 9 | 12 | 44 | .... | 4 | 11 | — | .... | 30 | 9 | 16 | .... | 26 | 7 | 32 |
| .... | 10 | 12 | 40 | .... | 5 | 10 | 56 | OCTOBER... | 1 | 9 | 12 | .... | 27 | 7 | 28 |
| .... | 11 | 12 | 36 | .... | 6 | 10 | 52 | .... | 2 | 9 | 8 | .... | 28 | 7 | 24 |
| .... | 12 | 12 | 32 | .... | 7 | 10 | 48 | .... | 3 | 9 | 4 | .... | 29 | 7 | 20 |
| .... | 13 | 12 | 28 | .... | 8 | 10 | 44 | .... | 4 | 9 | — | .... | 30 | 7 | 16 |
| .... | 14 | 12 | 24 | .... | 9 | 10 | 40 | .... | 5 | 8 | 56 | .... | 31 | 7 | 12 |
| .... | 15 | 12 | 20 | .... | 10 | 10 | 36 | .... | 6 | 8 | 52 | .................. | | | |
| .... | 16 | 12 | 16 | .... | 11 | 10 | 32 | .... | 7 | 8 | 48 | .................. | | | |


VISIBLE HEAVENS FROM JULY 22ND TO OCTOBER 31ST
URSA MAJOR
CANIS VENATICI
LYNX
AURIGA
CAMELOPARDALUS
POLAR STAR
URSA MINOR
BOOTES
CORONA BOREALIS
PERSEUS
CASSIOPEIA
CEPHEUS
DRACO
SERPENS
TAURUS
ECLIPTIC
TRIANGULUM
ANDROMEDA
CYGNUS
LYRA
HERCULES
ARIES
THE ZENITH
LACERTA
VULPECULA
OPHIUCHUS
PISCES
PEGASUS
DELPHINUS
EQUULEUS
EQUATOR
CETUS
AQUILA
SCUTUM
AQUARIUS
CAPRICORNUS
SAGITTARIUS
SCULPTORIS
PISCIS
EAST Rising
WEST Setting
STARS VISIBLE
NO.
MAG
7 of the 1st
31 2nd
93 3rd
220 4th
553 5th

# ZODIACAL LIGHT.

The **Zodiacal Light** is a faint luminous appearance, which accompanies the Sun, and is seen just after twilight in the evening, or before it commences in the morning. It was observed by Kepler, who supposed it to be the Sun's atmosphere, and afterwards accurately described by Cassini, in 1683, who gave it the name by which it is now known, in consequence of its always being in the Zodiac. It probably surrounds the sun on all sides; but is shaped like a lens, or burning glass, the circumference of which is directly over the Sun's equator. The edge being always presented to us gives it the appearance of a pyramid or cone. There can only that portion of it be seen which remains above the horizon after twilight has ceased. When seen, it extends from the horizon upwards, and following the course or path of the Sun. For this reason it is scarcely visible in our latitude, as the path of the Sun during most of the year, is very oblique to the horizon: consequently it is obscured by twilight, which does not cease until the Sun is 18 degrees below the horizon. At the equator it can be favorably observed most of the year, and often presents a beautiful appearance. The most favorable times for observing it in our latitude are in the evening, during the months of April and May, and in the morning during the months of October and November, as the path of the sun is nearer perpendicular to the horizon than at any other times during the year. It appears in form like a pyramid, with the base at the horizon—tapering to a point, and more or less inclined to the horizon.

Its length above the horizon varies, according to circumstances, from 40 to 100 degrees, and its breadth at the base perpendicular to its axis varies from 8 to 30 degrees. It is extremely faint and ill-defined in our climate; but is much more conspicuous in tropical countries. An allusion is made to this phenomenon in a work published by J. Childrey in 1661, in the following passage:—"In the month of February, for several years, about six o'clock in the evening, after twilight, I saw a path of light tending from the twilight towards the Pleiades, as it were touching them: this is to be seen whenever the weather is clear, but best when the moon does not shine. I believe that this phenomenon has been before visible, and will hereafter appear, always at the above mentioned period of the year; but the cause and nature of it I cannot guess, and therefore leave it to the inquiry of posterity."

Various opinions and theories have been advanced by astronomers, both ancient and modern; but none have been able to settle the point beyond controversy. Cassini thought it might proceed from an innumerable multitude of little bodies revolving around the Sun, reflecting a faint light, like that of the milky-way. Kepler ascribed its appearance to the atmosphere which he supposed to surround the Sun. Both of these theories have been discarded as being untenable. Professor Olmstead supposes it to be a nebulous body, or thin gaseous mass, revolving around the Sun, causing the Meteoric Showers that have occurred for several years in the month of November, in consequence of the earth's near approach to it, in its annual course around the Sun.

Herschell and Professor Nichol assert that the Zodiacal Light is a phenomenon precisely similar to that exhibited by the nebulous stars, and if we were living upon some distant star, the Sun would appear to us like a star surrounded by a faint light similar to that of a candle seen at a short distance, in a foggy or thick atmosphere.

The present theory of the Zodiacal Light may be summed up in a few words—*namely*, that the matter of which the Sun and planets are composed was originally in a thin gaseous state, and has been condensed into solid bodies, which form the Sun and planets; that the Zodiacal Light is a portion of this matter, which has not as yet subsided into the Sun. It is estimated to extend beyond the orbit of Mercury, and perhaps that of Venus; if so, they must pass through it twice during each revolution around the Sun.

## A SIMPLE METHOD TO FIND THE CIRCUMFERENCE OF THE EARTH.

All circles, great or small, are supposed to be divided into 360 equal parts, called degrees. From this it will be seen that a degree has no definite measure; but depends upon the magnitude of the circle. If we suppose a circle to be 360 miles in circumference, then one degree would measure just one mile; but if the circle were greater a degree would be greater, and if less a degree would be less. We will now apply this principle of the circle to measure the circumference of the earth. In order to do this, we must take two places some distance apart and under the same meridian; we will suppose New York and Albany.

We will suppose that the exact distance between the two places has been found by exact measurement to be 138½ miles—(this distance probably does not vary much from the truth.) We will now place an observer at each place with accurate instruments, and on a particular night, at 12 o'clock, the observer at New York finds a particular star exactly in his zenith, or over head; but the observer at Albany finds the same star two degrees to the south of his zenith,—hence it will be seen that there are two degrees between the two places; and as the distance, by measurement, was found to be 138½ miles, the two degrees between New York and Albany are equal to 138½ miles, or one degree equals 69¼ miles. Now, if we multiply the number of degrees in the whole circle or circumference of the earth (360) by 69¼ miles, it will give 24,930 miles the whole circumference of the earth.

# PRINCIPAL CONSTELLATIONS VISIBLE, FROM NOVEMBER 1 TO JANUARY 20.

**Perseus, and Medusa's Head.**—This constellation is directly in the zenith, or over head. It contains two stars of the 2d magnitude. The one in the breast of PERSEUS is called Mirzak, or Algenib; the other is ALGOL, in Medusa's head: it is about 15° east of the zenith. This star is remarkable on account of its changeableness. It changes in 4 hours from the 2d to the 4th magnitude. It remains in this condition 18 minutes, when it begins to increase in brightness; and in 4 hours and 40 minutes appears again of the 2d magnitude: in which state it continues 61 hours, when it begins to diminish again. Dr. Herschel attributes its variableness to spots upon its surface like those of the sun, and that it revolves upon its axis.

[*History.*—PERSEUS was the son of Jupiter and DANÆ. He was no sooner born than he was cast into the sea with his mother, and was driven on the coast of one of the islands of CYCLADES. Polydectes, the King of the place, treated them with kindness, and placed them in the care of the Priests of Minerva's Temple. He promised to present the King with the head of Medusa, the only one of the Gorgons who was subject to mortality. They were represented with serpents wreathing about their heads instead of hair; their bodies grew indissolubly together, and their very looks had the power of turning into stone all those on whom they fixed their eyes. Being equipped by the gods, he mounted into the air, conducted by Minerva, and came upon the monsters, who, with the watchful snakes, were asleep, and with one blow cut off her head. Perseus then made his way through the air, with Medusa's head yet bleeding, in his hand, and from the blood which dropped from it as he flew, sprang all those innumerable serpents that have ever since infested the sandy deserts of Lybia.]

**Triangulum, the Triangle.**—This is a small constellation southwest from Medusa's Head, in the constellation PERSEUS. It may be known by three stars, which form a triangle. This constellation is of recent origin.

**Aries, the Ram.**—This constellation lies to the southwest, about 30° from the zenith, and may easily be distinguished by three bright stars in the head of the RAM, and nearly in a right line. This constellation twenty-two centuries ago occupied the first sign in the ecliptic; or at that time the constellations of the zodiac and the signs of the ecliptic corresponded to each other: but in consequence of the retrograde motion of the equinoxes, 50″ a year, the constellations of the zodiac and the signs of the ecliptic have been separated from each other, by the falling back of the signs in the ecliptic about 31 degrees: so that the constellation Aries is now in the sign Taurus of the ecliptic; and Taurus in Gemini, and Gemini in Cancer; and so on. This constellation probably received its name from the Chaldean Shepherds, who were in those days the best astronomers, from the fact that their occupation led them to be on the watch during the night, to defend their flocks from the ravages of wild beasts. They observed that when the sun entered this division of the heavens the lambs were with their flocks, or that it was the season for the increase of their flocks—hence the Ram was very appropriately made to represent this sign.

**Taurus, the Bull.**—This constellation is south, about 30° from the zenith, and will be easily distinguished by the star ALDEBARAN, of the first magnitude, situated in the Bull's eye. There are two very important clusters in this constellation, the Hyades on the head, and the Pleiades on the neck of the Bull. This constellation probably derived its name, as well as the other signs of the zodiac, from some particular *phenomenon* which was apparent at that particular time. It was intended to show that this was the season for the increase of the ox species—hence the name Taurus, or Bull.

**Gemini, the Twins.**—This constellation is situated a little to the south of east, and may be known by two stars of the 2d magnitude, one in each head of the Twins—their names ($\alpha$) Castor and ($\beta$) Pollux. This sign was originally represented by two goats, and was probably intended to indicate the season for the multiplication of this animal, as well as to show that there were usually two at a birth.

**Cancer, the Crab.**—This constellation is next east of GEMINI. It contains stars only of the 4th magnitude. It was observed by the Ancients, that the sun, when it enters Cancer, passes sideway along the tropic, without crossing it, which was fitly represented by a crab, which moves sideways.

**Orion.**—This constellation is southeast of Taurus, and is one of the most conspicuous constellations in the heavens. It contains two stars of the first magnitude. (NOTE.—See description of Map No. 1.)

**Canis Minor, the Little Dog.**—This constellation is southeast of Gemini. It contains one star of the first magnitude, Procyon, and one of the 3d, MIRZA, in the head of the Dog.

**Canis Major, the Great Dog.**—This constellation is situated to the southeast, and near the horizon. The principal star is Sirius, the brightest star in the whole heavens. (NOTE.—See explanation to Map No. 1.)

**Lepus, the Hare.**—This constellation is south of ORION. It contains three stars of the 3d magnitude. It is situated west of the GREAT DOG, which seems to be pursuing it from east to west, owing to the motion of the earth on its axis. The hare is one of those animals which ORION delighted in hunting, and for this reason was made into a constellation, and placed near him, among the stars.

**Eridanus, the River Po.**—This constellation occupies a large space in the heavens directly south of TAURUS. It will be found difficult to trace it, in all its windings. Its entire height is 130 degrees. It commences near the star Rigel, in the foot of Orion. ERIDANUS is the name of a celebrated river in Italy, now known by the name of the river Po.

**Cetus, the Whale.**—This constellation occupies the largest space of any in the heavens, and is west of the RIVER PO. As the whale is the chief monster of the ocean, so is it the largest constellation in the heavens. It is considered to be the famous sea monster sent by Neptune to devour ANDROMEDA, because her mother, Cassiopeia had boasted herself fairer than JUNO, or the sea nymphs—but was slain by PERSEUS, and placed among the stars, in honor of his heroic deeds.

**Monoceros, the Unicorn.**—This constellation is east of ORION, and was made out of the unformed stars of the ancients, which lay scattered over a large space between the two dogs Canis Major and Canis Minor. The Monoceros is a species of Unicorn or RHINOCEROS. It is about the size of a horse, with one horn growing out of the middle of its forehead.

**Columba, the Dove.**—This constellation is south of the LEPUS, THE HARE. It is so near the horizon that it probably will not be visible. It was introduced among the constellations by Rogu in 1679.

**Camelopardalus, the Giraffe.**—This constellation was formed by HEVELIUS, in the beginning of the 17th century. It was made up of stars not included in the adjacent constellations, viz: PERSEUS, AURIGA, the head of URSA MAJOR, and the POLE STAR.

# MAP, FROM NOVEMBER 1 TO JANUARY 20.

[☞ The Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. There will be nine stars of the first magnitude above the horizon. The star Vega, in the Harp, being so near the northern horizon, may not be visible. There will be several of the most conspicuous constellations in the whole heavens visible, as well as a considerable number of stars of the first magnitude. The principal constellations are Auriga, Taurus, Orion, Canis Major, and Canis Minor. This is the best season for observation during the year, as the atmosphere is generally more clear than at any other time, and the stars twinkle with a beautiful brilliancy.]

## STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

AURIGA, The Charioteer—(**Capella** the principal star.)—This star is about 15° northeast of the zenith.

TAURUS, The Bull—(**Aldebaran.**)—This star is in the Bull's Eye, and is situated about 25° south of the zenith, and 5° east of the meridian.

CYGNUS, The Swan—(**Deneb.**)—This star is situated in the Milky Way, and west of the North Star, about midway to the horizon.

LYRA, The Harp—(**Vega.**)—This star is northwest of the North Star, and close to the horizon—probably not visible.

ORION, Orion—(**Betelgeuse.**)—This star is in the right shoulder of Orion, and situated southeast about 35 degrees.

" (**Rigel.**)—This star is on the left foot of Orion, southeast from Betelgeuse.

CANIS MAJOR, Great Dog—(**Sirius.**)—This star is situated southeast, about 20 degrees above the horizon.

CANIS MINOR, Little Dog—(**Procyon.**)—This star is southeast, and about 40 degrees above the horizon. It is nearly north of Sirius.

LEO MAJOR, Great Lion—(**Regulus.**)—This star is nearly east, and about 15° above the horizon.

# TABLE OF THE TIMES FOR OBSERVATIONS

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

| | | H. | M. | | | H. | M. | | | H. | M. | | | H. | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NOVEMBER.. | 1 | 1 | 28 | NOVEMBER | 24 | 11 | 56 | DECEMBER | 17 | 10 | 24 | JANUARY... | 9 | 8 | 56 |
| .... | 2 | 1 | 24 | .... | 25 | 11 | 52 | .... | 18 | 10 | 20 | .... | 10 | 8 | 52 |
| .... | 3 | 1 | 20 | .... | 26 | 11 | 48 | .... | 19 | 10 | 16 | .... | 11 | 8 | 48 |
| .... | 4 | 1 | 16 | .... | 27 | 11 | 44 | .... | 20 | 10 | 12 | .... | 12 | 8 | 44 |
| .... | 5 | 1 | 12 | .... | 28 | 11 | 40 | .... | 21 | 10 | 8 | .... | 13 | 8 | 40 |
| .... | 6 | 1 | 8 | .... | 29 | 11 | 36 | .... | 22 | 10 | 4 | .... | 14 | 8 | 36 |
| .... | 7 | 1 | 4 | .... | 30 | 11 | 32 | .... | 23 | 10 | — | .... | 15 | 8 | 32 |
| .... | 8 | 1 | — | DECEMBER | 1 | 11 | 28 | .... | 24 | 9 | 56 | .... | 16 | 8 | 28 |
| .... | 9 | 12 | 56 | .... | 2 | 11 | 24 | .... | 25 | 9 | 52 | .... | 17 | 8 | 24 |
| .... | 10 | 12 | 52 | .... | 3 | 11 | 20 | .... | 26 | 9 | 48 | .... | 18 | 8 | 20 |
| .... | 11 | 12 | 48 | .... | 4 | 11 | 16 | .... | 27 | 9 | 44 | .... | 19 | 8 | 16 |
| .... | 12 | 12 | 41 | .... | 5 | 11 | 12 | .... | 28 | 9 | 40 | .... | 20 | 8 | 12 |
| .... | 13 | 12 | 40 | .... | 6 | 11 | 8 | ... | 29 | 9 | 36 | .... | 21 | 8 | 8 |
| .... | 14 | 12 | 36 | .... | 7 | 11 | 4 | .... | 30 | 9 | 32 | .... | 22 | 8 | 4 |
| .... | 15 | 12 | 32 | .... | 8 | 11 | — | .... | 31 | 9 | 28 | .... | 23 | 8 | — |
| .... | 16 | 12 | 28 | .... | 9 | 10 | 56 | JANUARY... | 1 | 9 | 28 | .... | 24 | 7 | 56 |
| .... | 17 | 12 | 24 | .... | 10 | 10 | 52 | .... | 2 | 9 | 24 | .... | 25 | 7 | 52 |
| .... | 18 | 12 | 20 | .... | 11 | 10 | 48 | ... | 3 | 9 | 20 | .... | 26 | 7 | 48 |
| .... | 19 | 12 | 16 | .... | 12 | 10 | 44 | ... | 4 | 9 | 16 | .... | 27 | 7 | 44 |
| .... | 20 | 12 | 12 | .... | 13 | 10 | 40 | .... | 5 | 9 | 12 | .... | 28 | 7 | 40 |
| .... | 21 | 12 | 8 | .... | 14 | 10 | 36 | .... | 6 | 9 | 8 | .... | 29 | 7 | 36 |
| .... | 22 | 12 | 4 | .... | 15 | 10 | 32 | .... | 7 | 9 | 4 | .... | 30 | 7 | 32 |
| .... | 23 | 12 | — | .... | 16 | 10 | 28 | .... | 8 | 9 | — | .... | 31 | 7 | 28 |


VISIBLE HEAVENS FROM NOVEMBER 1ST TO JANY 20TH
HERCULES
LYRA
DRACO
URSA MINOR
CYGNUS
URSA MAJOR
LEO MINOR
LEO MAJOR
POLAR STAR
CEPHEUS
CAMELOPARDALUS
CASSIOPEIA
LACERTA
ANDROMEDA
LYNX
SEXTANS
AURIGA
PEGASUS
HYDRA
GEMINI
PERSEUS
TRIANGULUM
AQUARIUS
CANIS MINOR
ARIES
PISCES
TAURUS
ECLIPTIC
MONOCEROS
EQUATOR
ORION
Milky Way
CETUS
ARGO NAVIS
CANIS MAJOR
LEPUS
ERIDANUS
COLUMBA
STARS VISIBLE
No
MAG
9 of the 1st
35 2nd
92 3rd
210 4th
528 5th

## PROBLEMS PERFORMED WITH THE TERRESTRIAL GLOBE.

PROBLEM 1.—*To find the Latitude of any given place.*

RULE.—Bring the given place to the graduated side of the brass meridian, and the degree on the brass meridian over the place is the latitude, which is either north or south.

*Q.* What is the latitude of New York?

*A.* About 41 degrees north.

*Q.* What places have no latitude?

*A.* All places on the equator.

*Q.* Find the latitude of the following places:—

| | | | |
|---|---|---|---|
| London, | Philadelphia, | Boston, | Washington, |
| Edinburgh, | Rome, | Dublin, | Amsterdam, |
| Moscow, | Stockholm, | Quito, | Mexico, |
| Algiers, | Astoria, | Cape of Good Hope, | Halifax, |
| Norfolk, | Aleppo, | Athens, | Ispahan, |
| Madras, | Madrid, | Cape Horn, | Cairo, |
| Prague, | Dantzic, | Teneriffe, | Lisbon, |
| Tripoli, | Paris, | Lima, | Vienna. |

PROBLEM 2.—*To find the Longitude of any given place.*

RULE.—Bring the given place to the brass meridian, and the degree on the equator under the brass meridian, is the longitude. (*Note.*—Longitude is reckoned from the meridian of Greenwich, 180 degrees east and west.)

*Q.* What is the longitude of New York?

*A.* 74 degrees west.

*Q.* What is the longitude of Pekin?

*A.* 116 degrees east.

*Q.* Find the longitude of the following places:—

| | | | |
|---|---|---|---|
| Washington, | Hartford, | Sandwich Islands, | Gibraltar, |
| Quebec, | Rhodes, | Calcutta, | Constantinople, |
| Canton, | Havana, | Jerusalem, | Nankin, |
| Pekin, | St. Petersburgh, | Venice, | Berlin, |
| Astoria, | Cape Horn, | New Orleans, | Rio Janeiro. |

PROBLEM 3.—*To find any place whose latitude and longitude are given.*

RULE.—Bring the given longitude to the brass meridian, and under the given latitude is the place required.

*Q.* What place is situated in seventy-four degrees west longitude, and 41 north latitude?

*A.* New York.

*Q.* What places have the following latitudes and longitudes?

| | |
|---|---|
| Lat. 42° north, Lon. 71° west. | Lat. 34° south, Lon. 18° east. |
| Lat. 53° north, Lon. 6° west. | Lat. 41° north, Lon. 72° west. |
| Lat. 38° north, Lon. 9° west. | Lat. 39° north, Lon. 75° west. |
| Lat. 46° north, Lon. 75° west. | Lat. 32° north, Lon. 81° west. |

PROBLEM 4.—*To find all those places that are in the same latitude or longitude as a given place.*

RULE.—Bring the given place to the brass meridian; then all the places under the meridian have the same longitude; turn the globe round, and all places which pass under the latitude of the place have the same latitude.

*Q.* What places have nearly the same longitude as New York?

*A.* Albany, Montreal, Bogota.

*Q.* What places are in the same latitude?

*A.* Boston, Madrid, Naples, Constantinople.

*Q.* What places have the same longitude and latitude as the following places:—

| | | | | |
|---|---|---|---|---|
| Washington, | London, | St. Petersburgh, | Rome, | Cairo, |
| New Orleans, | Mexico, | Canton, | Calcutta, | Dublin? |

PROBLEM 5.—*To find the difference of Latitude between any two places.*

RULE.—Find the latitude of each place, and note them down; then if both places are on the same side of the equator, subtract the less latitude from the greater: if they are on the opposite sides of the equator, add the latitudes.

*Q.* What is the difference of latitude between New York and London?

*A.* New York 41° north, London 51° north; difference 10°

*Q.* What is the difference of latitude between Washington and Cape Horn?

*A.* Washington 37° north, Cape Horn, 56° south.—Sum 93.°

*Q.* Find the difference of latitude between the following places:—

| | |
|---|---|
| New Orleans and Quebec. | Mexico and Rio Janeiro, |
| Madrid and Cairo, | Pekin and Botany Bay, |
| St. Petersburgh and Rome, | Cape of Good Hope and Cape Horn. |

PROBLEM 6.—*To find the difference of longitude between any two places.*

RULE.—Find the longitude of each place, and note them down; then, if both places are east or west of the meridian, subtract the less longitude from the greater; but if one is east and the other west add the longitudes.

*Q.* What is the difference of longitude between New York and New Orleans?

*A.* New York 74°; New Orleans 90°, west—difference 16 degrees.

*Q.* What is the difference in longitude between Boston and Rome?

*A.* Boston 71° west; Rome 12° east—sum, 83 degrees.

If the sum of the longitudes exceed 180 degrees, subtract it from 360 degrees; the remainder will be the difference in longitude; as, Astoria 124° west; Pekin 116° east=240 : 360−240=120° difference in longitude.

PROBLEM 7.—*The hour of the day at any place being given, to find what o'clock it is at any other place.*

RULE.—Bring the place at which the time is given to the brass meridian; set the index to the given hour, then turn the globe till the proposed place comes to the meridian; the index will point to the hour required. If the place required is east of the given place, it is later; if to the west, it is earlier.

*Q.* When it is noon at New York, what is the time in London?

*A.* 4 o'clock 56 min.

*Q.* When it is noon at Washington, what is the hour at

| | | | | | |
|---|---|---|---|---|---|
| New Orleans, | Mexico, | Quebec, | Boston, | Astoria, | Pekin, |
| Cape Horn, | Rome, | St. Petersburgh, | Moscow, | Canton, | Dublin? |

When it is midnight at New York, what is the hour at

| | | | | | |
|---|---|---|---|---|---|
| Paris, | Cairo, | Calcutta, | St. Helena, | Gibraltar, | Havana, |
| Constantinople, | Mexico, | Astoria, | Nankin, | Tunis, | Cadiz? |

PROBLEM 8.—*The hour of the day being given at any place, to find all places on the globe where it is then noon, or any other given hour.*

RULE.—Bring the place to the brass meridian; set the index to the hour of that place; turn the globe till the index points to the other given hour; then all places under the brass meridian will be the places required.

PROBLEM 9.—*To find the Antœci of any place.*

RULE.—Bring the place to the brass meridian, and find its latitude, then, under the same degree of latitude, on the opposite side of the equator will be the *Antœci.*

PROBLEM 10.—*To find the Periœci of any place.*

RULE.—Bring the given place to the brass meridian, and set the index to twelve; turn the globe till the index points to the other twelve, and under the same degree of latitude will be the *Periœci.*

PROBLEM 11.—*To find the Antipodes of any place.*

RULE.—Bring the place to the brsss meridian, and find its latitude, set the index to twelve, and turn the globe till the index points to the other twelve; then under the same degree of latitude, on the other side of the equator, will be the antipodes.

PROBLEM 12.—*To find the distance in miles between any two places on the globe.*

RULE.—Lay the quadrant of altitude over the two places, so that the division marked 0 will be on one of the places, and it will show the number of degrees between them; which, multiplied by 69½ will give the distance in miles.

PROBLEM 13.—*To find the Sun's Longitude or place in the Ecliptic, and his declination, in any given month or day.*

RULE.—Look for the given day in the circle of months on the wooden horizon, and opposite to it, in the circle of signs, are the sign and degree in which the sun is for that day. Find the same sign and degree in the ecliptic on the surface of the globe; bring the degree of the ecliptic, thus found, to the brass meridian, and the degree of the meridian will be the declination.

PROBLEM 14.—*To find the time at which the Sun rises and sets at any place, the day in the year, and the length of the day and night at that place.*

RULE.—Raise the pole (of the hemisphere in which the place is situated) as many degrees above the horizon as are equal to the latitude of the place; bring the sun's place on the given day, to the meridian, and set the index to 12: bring the sun's place to the eastern horizon, and the index will show the time of the sun's rising; bring the sun's place to the western edge of the horizon, and the index will show the hour of setting. Double the time of the sun's setting, and the length of the day will be had; double the time of the sun's rising, and the length of the night will be had.

PROBLEM 15.—*To find the length of the longest and shortest days and nights at any place on the earth.*

RULE.—If the place is in the northern hemisphere, elevate the north pole till the horizon cuts the brass meridian in the degree corresponding to the latitude of the place; bring the first degree of Cancer to the meridian, and set the index to 12; find the sun's place in the ecliptic, (by problem 13,) and bring it to the eastern edge of the horizon, and the index will show the hour of the sun's rising; double this time, and it will give the length of the longest night. Bring the sun's place to the western edge of the horizon, and the index will show the hour of setting; double this time, and you will have the length of the longest day at that place. If the place is in the southern hemisphere, elevate the south pole to correspond with the latitude of the place; bring the first degree of Capricorn to the meridian, and proceed as above.

*Q.* What is the length of the longest day and shortest night at New York?

*A.* Longest day, 14 h. 56 min.; shortest night, 9 h. 4 min.

PROBLEM 16.—*To find those places where the Sun does not rise or set on a given day.*

RULE.—Find the sun's declination on the given day, (by prob. 13,) raise the pole (nearest to the sun's place,) as many degrees above the horizon as are equal to the declination; turn the globe round on its axis, and at all places that do not come above the horizon the sun does not rise on that day; and at all places around the other pole that do not pass below the horizon, the sun does not set on that day.

## PROBLEMS PERFORMED WITH THE CELESTIAL GLOBE.

[**Latitude,** on the Celestial Globe, is reckoned 90°, either north or south, on circles of Celestial Latitude, which are at right angles to the ecliptic. (SEE DIAGRAM, PAGE 55.)

**Longitude,** on the Celestial Globe, is reckoned on the ecliptic, from the first degree of ARIES, eastward, round the globe.

**Declination,** is reckoned from the equinoctial, either north or south.

**Right Ascension,** is reckoned on the equinoctial, from the first degree in ARIES, eastward, round the globe.]

PROBLEM 1.—*To find the Right Ascension and Declination of the Sun or a Star.*

RULE.—Bring the sun or star to that part of the brass meridian which is numbered from the equinoctial towards the poles: the degree on the brass meridian, over the place, will show the declination; and the number of degrees on the equinoctial, between the brass meridian and the first point of Aries, is the right ascension.

*Required*—the right ascension and declination of the following stars:

| | |
|---|---|
| Aldebaran, in Taurus, | Arcturus, in Bootes, |
| Sirius, in the Great Dog, | Capella, in Auriga, |
| Vega, in the Harp, | Regulus, in Leo. |

PROBLEM 2.—*To find the Latitude and Longitude of a Star.*

RULE.—Place the end of the quadrant of altitude, which is marked 90°, on the north or south pole of the ecliptic, according as the star is north or south of the ecliptic; then move the other end till the graduated edge of the quadrant comes to the star. The number of degrees on the quadrant, between the ecliptic and the star, is the latitude; and the number of degrees on the ecliptic, reckoned eastward, from the first point of Aries to the quadrant, is the longitude.

EXAMPLE.—*Required*, the latitudes and longitudes of the following stars:—

Aldebaran in Taurus. *Ans.* Latitude 5° 28′ S.; longitude, 2 signs 6° 53′, or 6° 53′ in Gemini.

| | |
|---|---|
| Deneb, in the Swan, | Altair, in the Eagle, |
| Antares, in Scorpio, | Rigel, in Orion, |
| Fomalhaut, in the S. Fish, | Pollux, in Gemini. |

PROBLEM 3.—*The declination and right ascension of a Star, the Moon, a Planet, or a Comet, being given, to find its place on the globe.*

RULE.—Bring the given degrees of right ascension to that part of the brass meridian which is numbered from the equinoctial towards the poles; then under the given declination on the brass meridian you will find the star or planet.

*Q.* What stars have the following right ascensions and declinations?

| Right Ascension. | Declination. | Right Ascension. | Declination. |
|---|---|---|---|
| 76° 14′ | 8° 27′ S. | 86° 13′ | 44° 55′ N. |
| 83 6 | 34 11 S. | 99 5 | 16 26 S. |
| 25 54 | 19 50 N. | 11 11 | 59 38 N. |
| 53 54 | 23 29 N. | 46 32 | 9 34 S. |

PROBLEM 4.—*The latitude and longitude of the Moon, a Star, or a Planet, being given, to find its place on the globe.*

RULE.—Screw the quadrant of altitude on the pole of the ecliptic, and place the other end on the given degree of longitude in the ecliptic; then, under the given latitude, on the graduated edge of the quadrant, you will find the star, or place of the moon or planet.

*Q.* What stars have the following latitudes and longitudes?

| Latitudes. | Longitudes. | Latitudes. | Longitudes. |
|---|---|---|---|
| 16° 3′ S. | 2s 25° 51′ | 10° 4′ N. | 3s 17° 21′ |
| 22 52 N. | 2 18 57 | 21 6 S. | 11 0 56 |
| 5 29 S. | 2 6 53 | 12 3 S. | 1 11 25 |
| 44 20 N. | 7 9 22 | 0 27 N. | 4 26 57 |

PROBLEM 5.—*The latitude of a place, the day and hour being given, to place the globe in such a manner as to represent the heavens at that time, in order to point out the situations of the constellations and remarkable stars.*

RULE.—Elevate the pole for the latitude of the place, and set the globe due north and south by a meridian line; find the sun's place in the ecliptic, bring it to the brass meridian, and set the index to 12. If the time be afternoon, turn the globe westward; if in the forenoon, turn the globe eastward, till the index points to the given hour. The surface of the globe then represents the appearance of the heavens at that time and place.

PROBLEM 6.—*To find the distance of the Stars from each other, in degrees.*

RULE.—Lay the quadrant of altitude over any two stars, so that the division marked 0 may be on one of the stars: the degrees between them will show their distance, or the angle which these stars subtend, as seen from the earth.

EXAMPLE.—What is the distance, in degrees, between the two stars Vega and Altair? *Ans.* 34 degrees.

Also, between Regulus and Procyon,
" " Aldebaran and Sirius,
" " Arcturus and Spica,
" " Capella and the North Star?

# GLOSSARY,

## OR EXPLANATION OF ASTRONOMICAL TERMS.

*ABERRATION.*—An apparent annual motion in the fixed stars, occasioned by the velocity of light combined with the real velocity of the earth in its orbit.

*Absorbent Media.*—Substances either solid, liquid, or fluid, which imbibe the rays of light and heat.

*Acceleration.*—An increase in the rapidity of the motion of a moving body. The motions of the planets are accelerated from their aphelion to their perihelion.

*Acronycal.*—A star is said to rise or to set acronycally when it rises or sets at the instant of sunset.

*Aëriform.*—Having the form of air.

*Aërolite.*—A meteoric stone.

*Air or Atmosphere.*—A transparent, invisible, elastic fluid, surrounding the earth, in which we move and breathe.

*Altitude.*—The height of an object above the horizon.

*Amphiscii.*—A name applied to the inhabitants of the torrid zone, because within the year, their shadows, at noon, are cast both north and south.

*Amplitude.*—The distance which a heavenly body rises from the east, or sets from the west point of the horizon.

*Analemma.*—A figure on the artificial globe, drawn from one tropic to the other, on which is marked the sun's declination for each day in the year.

*Angle.*—The corner or opening between two lines that meet. A right angle contains 90 degrees, and is formed by one line falling perpendicularly upon another. An acute or sharp angle is less than a right angle. An obtuse or blunt angle is greater than a right angle. The measure of an angle is always an arc.

*Angle of Position of a Double Star.*—The angle which a line joining the two stars makes with one parallel to the meridian.

*Angular Distance.*—The distance between two objects, which is indicated by the angle, made by straight lines drawn to them from a given point.

*Annual Equation.*—A periodical inequality in the motion of the moon, or a planet, going through its changes in a year.

*Annual Revolution of the Earth.*—Its yearly revolution round the sun.

*Annular.*—Having the form of a ring.

*Anomaly.*—The sun's angular distance from the apogee, or the earth's from aphelion.

*Antarctic Circle.*—A circle round the south pole, 23° 28' from it.

*Antipodes.*—Those who live on directly opposite sides of the earth.

*Antœci.*—Those who live in equal latitude on directly opposite sides of the equator.

*Aphelion.*—The point in a planet's orbit which is farthest from the sun.

*Apogee.*—The point of the orbit of the moon or a planet farthest from the earth.

*Apparent Diameter.*—The diameter of a body as seen from the earth.

*Apparent Motion.*—The motion of the heavenly bodies as viewed from the earth.

*Apparent Time.*—The time shown by the sun, as indicated by a dial.

*Apsis.*—The point of an orbit which is at the greatest or least distance from the centre of motion. The former is called the higher apsis; the latter the lower apsis. The two together are termed the apsides, and a line uniting them is called the apsis line, or line of the apsides.

*Aquarius.*—The eleventh sign of the ecliptic.

*Arc.*—Any part of the circumference of a circle.

*Arctic Circle.*—A circle round the north pole, 23° 28' from it.

*Areas.*—In astronomy, they are the spaces passed over by the radius vector of a celestial body.

*Aries.*—The first sign of the ecliptic. Its first point is at the vernal equinox.

*Argument.*—A quantity by which another quantity or equation is found.

*Ascensional Difference.*—The difference between right and oblique ascension.

*Aspect.*—The appearance of the heavenly bodies with respect to position, angular distance, &c.

*Asteroids.*—Eight small primary planets, whose orbits are between those of Mars and Jupiter. Their names are Vesta, Astræa, Juno, Ceres, Pallas, Hebe, Iris and Flora. Some suppose them to be fragments of a planet, burst by some internal explosion.

*Astronomical Time.*—Time reckoned from the noon of one day up to 24 hours, to the noon of the next day. It consequently is made up of the last 12 hours of the same civil day, and the first 12 hours of the next civil day.

*Atmosphere.*—The air that surrounds the earth.

*Attraction.*—The power of one body to draw another towards it.

*Austral.*—Southern.

*Aurora.*—The morning, or the morning twilight.

*Aurora Borealis, or Northern Lights.*—A luminous appearance in the heavens, usually seen in high latitudes, and so named from its frequent resemblance to the morning dawn.

*Axis of Rotation.*—The line around which a revolving body turns.

*Axis of an Ellipse.*—The major axis is the greatest diameter. The minor axis is the least diameter.

*Azimuth.*—The distance of a heavenly body east or west of the meridian, which is indicated by the angle between the meridian and the vertical circle passing through the body.

*Azimuth, or Vertical Circle.*—A great circle in the heavens, passing through the zenith and nadir, and cutting the horizon at right angles.

*Binary System of Stars.*—Two stars revolving about each other.

*Bissextile, or Leap Year.*—Every fourth year, in which February has 29 days.

*Body.*—In astronomy this term is applied to any one of the celestial orbs.

*Calendar.*—A term applied to the Almanac, or the divisions of time of which it treats.

*Calendar Months.*—The months as laid down in the almanac.

*Cancer.*—The fourth sign of the ecliptic.

*Capricorn.*—The tenth sign of the ecliptic.

*Cardinal Points.*—The east, west, north and south points of the horizon.

*Centrifugal Force.*—The force which urges a revolving body forward in its orbit, or tends to carry it away from the centre of motion.

*Centripetal force.*—The force which draws a revolving body towards the centre of motion.

*Chord.*—A straight line from one end of an arc to the other.

*Circle.*—A figure bounded by a curve line, every part of which is equally distant from the centre. A great circle is one whose plane divides a globe into two equal parts called hemispheres; a small circle is one whose plane divides a globe into unequal parts.

*Circle of Declination.*—The circle where the plane of the meridian meets the heavens.

*Circle of Illumination.*—The circle that divides the enlightened from the dark hemisphere.

*Circumference.*—The boundary of a circle. The circumference of every circle is supposed to be divided into 360 equal parts, called degrees; each degree into 60 equal parts, called minutes; and each minute into 60 equal parts, called seconds.

*Circumpolar Stars.*—Those stars which revolve around the pole without passing below the horizon.

*Clouds.*—Vapor, in the atmosphere, condensed into small drops of water, and thus rendered visible.

*Colures.*—Those two meridians which pass through the equinoctial and solstitial points of the ecliptic, called the equinoctial and solstitial colures.

*Comet.*—A body with a luminous train or tail, moving around the sun in a very elongated orbit.

*Complement of an Arc or Angle.*—What it wants of 90 degrees.

*Concave.*—Hollowing in a circular manner.

*Concentric Circles.*—Circles having the same centre.

*Cone.*—A solid with a circular base, and tapering equally upwards to a point.

*Conjunction.*—Two heavenly bodies are in conjunction when they have the same longitude. A planet is in inferior conjunction when it is between the earth and sun; in superior conjunction when it is beyond the sun. The inferior planets only have inferior conjunction, but all have superior conjunction.

*Constellations.*—Groups of stars to which the names of men and animals were anciently given. The whole starry firmament is divided into such groups.

*Convex.*—Rounding out in a circular manner.

*Cosmical.*—The rising or setting of a star is said to be cosmical, when it rises or sets at the moment of sunrise.

*Cube.*—A square solid of six equal sides.

*Culminate.*—To pass the highest point of the diurnal arc, which is at the meridian.

*Culmination.*—The passing over the meridian, or point of highest altitude.

*Cycle.*—A period of time in which the same phenomena or circumstances of a body begin to occur again in the same order.

*Cycle of the Moon, or Metonic Cycle.*—A period of 19 years; after which the changes of the moon return to the same days of the month (when five leap years are included,) as on the same year of the preceding cycle, or 19 years before.

*Cycle of the Sun.*—A period of 28 years; after which the same days of the month return to the same days of the week, and the sun's place, to the same degrees and minutes of the ecliptic as on the same year of the preceding cycle.

*Cycle of a Planet.*—A period during which a planet passes through its various positions with respect to the sun and earth.

*Cylinder.*—A round figure or solid of equal size from end to end.

*Cylindrical.*—Having the form of a cylinder.

*Declination.*—The angular distance of a heavenly body, north or south, from the equinoctial.

*Degree.*—One 360th part of the circumference of a circle.

*Diagonal.*—A line drawn from corner to corner of a four sided figure.

*Dial.*—An instrument showing the hour of the day, by the shadow of the sun.

*Diameter.*—A straight line passing through the centre of a figure, and terminated both ways by its sides or surface. The longest and shortest diameters of an ellipse are called the transverse and conjugate diameters.

*Dichotomized.*—Divided into equal and similar parts, as the disc of the moon at quadrature.

*Digit.*—One-twelfth part of the apparent diameter of the sun or moon.

*Direct motion of a Planet.*—Apparent motion from west to east, according to the order of the signs.

*Disc.*—The apparent surface of a heavenly body.

*Diurnal Arc.*—The arc described by a heavenly body from its rising to its setting.

*Diurnal Revolution of the Earth.*—Its daily rotation on its axis, from west to east.

*Dominical Letter.*—The letter in the calendar against Sunday; the first 7 letters of the alphabet being applied to the first 7 days of the year.

*Dionysian Period.*—A period of [illegible] years; found by multiplying the cycles of the sun and moon.

*Earth.*—The globe on which we live.

*East.*—The direction in which the sun rises at the equinoxes.

*Eccentric.*—Deviating from the centre; irregular.

*Eccentric Circles.*—Those that are wholly or partially included in each other, but have different centres.

*Eccentricity.*—The distance from the centre of an ellipse to either of its foci.

*Ecliptic.*—The circle, where the plane of the earth's orbit meets the heavens.

*Egress.*—The act of going out.

*Element.*—Fundamental principle; quantity by which something else is found.

*Elevation.*—Height or altitude.

*Ellipse.*—An oval; a figure made by the oblique section of a cone.

*Elongation.*—The angular distance of a planet from the sun, or the difference of their celestial longitude.

*Emersion.*—The act of rising out of something, or re-appearing.

*Epact.*—The age of the moon at the commencement of the year.

*Epicycle.*—The curve described by a point of one circle, revolving upon another circle.

*Epoch or Era.*—A particular time, from which events are reckoned.

*Equation.*—A quantity to be applied to *mean* time, place, or motion, in order to find the *true*.

*Equator.*—A great circle, whose plane is perpendicular to the earth's axis.

*Equinoctial or Celestial Equator.*—The circle, where the plane of the equator meets the heavens.

*Equinoctial Points.*—The points where the equinoctial cuts the ecliptic, or the first points of Aries and Libra.

*Equinox.*—The time when the sun enters either of the equinoctial points. The vernal equinox occurs in March, the autumnal in September.

*Evection.*—A periodic inequality in the motion of the moon.

*Firmament.*—The heavens, or orb of fixed stars.

*Fixed Stars.*—Those stars which preserve the same situation with respect to each other.

*Foci.*—The plural of focus; the two points round which an ellipse is drawn.

*Fogs or Mist.*—Vapor, condensed into minute drops of water, as in clouds.

*Frustum.*—What remains of a regular figure after a piece is cut off by a plane parallel to its base.

*Galaxy or Milky Way.*—A luminous zone in the heavens, composed of an immense number of fixed stars.

*Geocentric.*—As seen from the earth, or the earth being the centre.

*Gibbous.*—The shape of the illuminated part of the moon, when more than half and not the whole of its disc is visible.

*Globe.*—A sphere, ball, or round body. Artificial globes of two kinds are made; the terrestial, to represent the earth; and the celestial, to represent the heavens.

*Golden Number.*—The number of years in the cycle of the moon since the epact was nothing.

*Gravitation or Gravity.*—The attraction or power which draws all bodies towards each other. Also, its effect, as weight, caused by the earth's attraction.

*Hail.*—Drops of rain, frozen while falling.

*Harvest Moon.*—The full moon nearest the autumnal equinox.

*Heliacal.*—The heliacal rising or setting of a star takes place, when it rises a little before or sets a little after the sun.

*Heliocentric.*—As seen from the sun, or the sun being the centre.

*Hemisphere.*—Half a sphere or globe.

*Heteroscii.*—A name given to the inhabitants of the two temperate zones, because at noon those in the northern always have their shadows in an opposite direction to those in the southern.

*Horizon.*—The visible or sensible horizon is the circle where the sky and earth appear to meet. The rational horizon is parallel to the visible, and its plane divides the earth into upper and lower hemispheres. It is represented on the artificial globe by the wooden horizon. The circle where its plane meets the heavens is called the celestial horizon.

*Horizontal.*—Level or parallel to the horizon.

*Hour Circle.*—A small circle, on the globe, near the north pole, having on it the hours of the day.

*Immersion.*—The act of plunging into something, or disappearing.

*Inclination.*—Angle. A position forming an acute angle.

*Index.*—A movable hand on the globe, to point out the time on the hour circle.

*Ingress.*—An entrance.

*Intercalation.*—The insertion of an extra day in the calendar, as the Bissextile.

*Julian Period.*—A period of 7,980 years, found by multiplying together the cycles of the sun and moon, and the Roman Indiction.

*Julian Year.*—A period of exactly 365¼ days.

*Latitude on the Earth.*—The distance of a place north or south of the equator.

*Latitude in the Heavens.*—The angular distance of a heavenly body from the ecliptic.

*Leap Year.*—Every fourth year, in which an extra day is added to the calendar.

*Leo.*—The fifth sign of the ecliptic.

*Libra.*—The 7th sign of the ecliptic.

*Libration of the Moon.*—A periodical oscillation of her disc.

*Limb.*—The curved edge of the sun or moon's disc.

*Line.*—That which has length but no breadth.

*Longitude on the Earth.*—Distance east or west of the first meridian.

# GLOSSARY, OR EXPLANATION OF ASTRONOMICAL TERMS, (CONTINUED.)

*Longitude in the Heavens.*—The angular distance of a heavenly body, measured on the ecliptic eastward, from the first point of Aries.

*Luminous.*—Capable of shining without light from another body.

*Lunar Distance.*—The angular distance of the centre of a celestial object from the centre of the moon.

*Lunar Month.*—The time from one new moon to the next.

*Lunation.*—The average time of the lunar month.

*Mariner's Compass.*—An instrument with a magnetic needle, to point out the horizontal direction.

*Mass.*—The quantity of matter in a body.

*Mean.*—Average; applied to distance, longitude, motion, place, time, &c.

*Meridian of a Place.*—A great circle passing through the place and the poles of the earth. The first meridian is the one from which longitude is reckoned. The brazen meridian is that in which the artificial globe turns.

*Meteor.*—A transitory object in the air. Falling stones are often called meteorites.

*Minute.*—One 60th part of a degree; also one 60th part of an hour.

*Moon's Southing.*—The time when the moon comes to the meridian of a place.

*Nadir.*—A point directly opposite to the zenith, or beyond the centre of the earth.

*Neap Tide.*—The least flood and ebb tide.

*Nebulæ.*—Clusters of Stars, or other causes of the luminous appearances in the heavens.

*Nocturnal Arc.* The arc described by a heavenly body from its setting to its rising.

*Nonagesimal Degree.*—The highest point of the ecliptic above the horizon.

*Node.*—The point of the moon's or a planet's orbit that is cut by the plane of the ecliptic. There are two nodes, one on each side of the centre of motion; and a line joining them is called the line of the nodes. The place where the body passes to the north of the ecliptic is called the ascending node; the other the descending node.

*New Style.*—The reckoning of time established by Gregory XIII., and now generally adopted.

*North.*—That point of the horizon which is directly towards the northern pole.

*Nucleus of a Comet.*—The part of its head which appears to be dense.

*Nutation.*—A variation in the direction of the earth's axis, caused by the attraction of the moon on the protuberant matter at the terrestrial equator.

*Oblique.*—Forming an acute or obtuse angle; not perpendicular.

*Oblique Ascension.*—That degree of the equinoctial which rises with a body in an oblique sphere.

*Oblique Descension.*—That degree of the equinoctial which sets with a body in an oblique sphere.

*Obliquity.*—Deviation from parallelism and from perpendicularity.

*Obliquity of the Ecliptic.*—The angle formed by the equinoctial with the plane of the ecliptic.

*Occidental.*—To the west, where the heavenly bodies appear to descend.

*Occultation.*—The eclipse of a star or planet by the moon or by another planet.

*Octant.*—Forty-five degrees distant, or the eighth part of a circle.

*Old Style.*—That reckoning of time which makes *every* fourth year a leap year.

*Opake.*—Not luminous or transparent.

*Opposition.*—Two bodies are in opposition when they are on opposite sides of the earth.

*Orbit.*—The path in which one body moves round another.

*Oriental.*—Towards the east, where the heavenly bodies rise.

*Parallax.*—The difference of the place of a body, as seen from different points of view. Diurnal parallax is the difference between the apparent and true place of a body. Horizontal parallax is the diurnal parallax of a body in the horizon. Annual parallax is the difference of the apparent place of a body, as seen from different parts of the earth's orbit.

*Parallactic Motion.*—Angular motion sufficiently great to be perceived.

*Parallel Lines.*—Those continued in the same direction, at the same distance from each other. Parallels of altitude, declination, and latitude, are small circles parallel to the horizon, equinoctial, and equator.

*Penumbra.*—A partial or imperfect shadow.

*Perigee.*—The point nearest the earth, in the orbit of the moon or a planet.

*Perioeci.*—Those who live in equal latitude on opposite sides of the pole.

*Perihelion.*—The lower apsis, or point nearest the sun, in a planet's orbit.

*Periodic Inequality.*—An irregularity in the motion of a celestial body, requiring a comparatively short time for its accomplishment.

*Periodic Time.*—The time in which a heavenly body revolves around its centre of motion.

*Periscii.*—A name given to the inhabitants of the frigid zone, because their shadows turn all round them in one day.

*Perpendicular.*—Making a right angle with some line or surface.

*Perturbations.*—Irregularities in the motions of bodies, from some disturbing cause.

*Phases.*—Different appearances of the moon and planets as they are differently illuminated.

*Phenomena.*—Appearances in the works of nature. (Singular Phenomenon.)

*Physical.*—Belonging to material nature.

*Pisces.*—The 12th sign of the ecliptic.

*Plane.*—Length and breadth without thickness. The plane of a circle is the surface contained within it, and continued out of it on all sides, indefinitely, to the heavens.

*Planet.*—An opake body revolving around the sun. The secondary planets revolve around the primary planets, as well as around the sun. Those planets nearer to the sun than the earth is, are called inferior; those more distant are called superior.

*Pleiades.*—The seven stars in the constellation Taurus.

*Point.*—That which has position but no magnitude.

*Polar Circles.*—Small circles drawn around the poles, 23½ degrees from them.

*Polar Distance.*—Angular distance from the pole, measured on a circle of declination.

*Poles.*—The terrestrial poles are the extremities of the earth's axis. The celestial poles are the points where the earth's axis, if produced, would meet the heavens.

*Pole Star.*—A star of the second magnitude, near the north pole of the heavens.

*Pointers.*—Two stars in the great bear, that serve to point out the pole star.

*Precession of the Equinoxes.*—A retrograde motion, on the ecliptic, of the equinoctial points, caused by the action of the sun and moon upon the protuberant matter at the earth's equator.

*Quadrant.*—Ninety degrees, or a quarter of a circle. An instrument to measure angles.

*Quadrature.*—The position, a quarter of a circle from the sun.

*Quadrilateral Figure.*—One that has four sides.

*Quartile.*—Ninety degrees distant from each other.

*Quiescent.*—At rest; not in motion.

*Radiation.*—An emission of rays.

*Radius.*—A straight line from the centre of a circle or sphere to its circumference.

*Radius Vector.*—A straight line between a planet and the sun, or centre of motion.

*Rain.*—Drops of water falling from the clouds.

*Reflection.*—The turning back of rays of light or sound from a surface.

*Refraction.*—The breaking or bending of a ray of light in passing through media of different densities.

*Repulsion.*—The property by which bodies recede or fly from each other.

*Retrograde Motion of a Planet.*—Apparent motion from east to west, contrary to the order of the signs.

*Revolution.*—Motion from a point round to the same again.

*Right Ascension.*—The distance east on the equinoctial from the first point of Aries.

*Right Line.*—A straight line; a direct course.

*Roman Indiction.*—A period of 15 years.

*Rotation.*—The motion of a body round its axis.

*Satellite.*—A moon, or secondary planet.

*Scorpio.*—The eighth sign of the ecliptic.

*Secondary Circles.*—Such as are in planes that are perpendicular to those circles of which they are the secondaries.

*Sector of a Circle.*—Space enclosed by two radii and an arc, less than a semicircle.

*Secular Inequalities.*—Variations in the motions of the heavenly bodies, requiring many ages for their accomplishment.

*Segment.*—Any part of the surface of a circle cut off by a cord.

*Semicircle.*—Half a circle. Half of the circumference, or an arc of 180 degrees.

*Sidereal Day.*—The time included between two consecutive transits of the same star at the same meridian. This period is invariably of exactly the same continuance; and it is the only one in nature, with which we are acquainted, that is so. Hence it forms a perfect standard measure, by reference to which all portions of time may be ascertained. Astronomical clocks are made to show sidereal time. It may likewise be observed that our standard measures of length, capacity, and weight, depend upon the equable rotation of the earth on its axis, as they are referred to the length of a pendulum beating seconds of mean time.

*Sign.*—Thirty degrees, or the 12th part of a circle. The ascending signs of the ecliptic are those in which the sun's meridian altitude is daily increasing.

*Snow.*—Water frozen while in the form of clouds, mist, or fine rain, which then falls gently to the earth.

*Solar Day.*—The time from one noon to the next, is the apparent, and the average time of that period, the mean, solar day.

*Solar System.*—The sun, with its planets and comets arranged regularly, in their several positions.

*Solstices.*—The times at which the sun is in the solstitial points. When the sun is at the summer solstice all places in the northern hemisphere have their longest day. These days vary in length from 12 hours at the equator to 24 at the arctic circle, and in the frigid zone they increase from 24 hours at the arctic circle to 6 months at the pole, where there is but one day and night during the year. At the same time all places in the southern hemisphere have their *shortest* day. These vary from 12 hours at the equator to nothing at the antarctic circle, where the sun does not rise above the horizon. The length of the *days* in south latitude corresponds to the length of the *nights* in north latitude; and the length of the *nights* in south latitude corresponds to the length of the *days* in north latitude. When the sun is at the winter solstice, this condition of things is reversed, and the southern hemisphere presents the same phenomena, with respect to the sun, as does the northern when the sun is at the summer solstice.

*Solstitial Points.*—The points of the ecliptic which are farthest from the equinoctial.

*South.*—That point of the horizon which is directly opposite to the north pole.

*Sphere.*—A globe or ball. A solid which has every point of its surface equally distant from its centre. Also, the concave expanse of the heavens that surrounds the earth. The sphere has three positions, right, oblique and parallel. Those who live at the equator have a right sphere, all the circles of daily motion rising directly above, and descending directly below the horizon. Those who live between the equator and poles have an oblique sphere, all the circles of daily motion being oblique to the horizon. Were any one at either of the poles he would have a parallel sphere, all the circles of daily motion being parallel to the horizon. On the artificial globe a right sphere is represented by placing both poles in the horizon; an oblique sphere by raising one pole a little and depressing the other; a parallel sphere, by bringing one pole to the zenith and the other to the nadir.

*Spherical.*—Having the form of a sphere.

*Spheroid.*—A solid resembling a sphere. If the polar diameter be the least, it is called an oblate spheroid; if it be the greatest, it is called a prolate or oblong spheroid.

*Spring Tide.*—The greatest flood and ebb tide.

*Stationary.*—A term applied to the apparent motion of a planet, when its real motion, combined with that of the earth, causes it to remain at the same point in the heavens.

*Supplement of an arc or angle.*—What the arc or angle wants of 180 degrees.

*Surface.*—That which has length and breadth, but no thickness.

*Synodic Month.*—A complete lunation, or from one new moon to another; it being 29 days, 12 hours and 44 minutes.

*Syzygies.*—The points in the moon's orbit where she is new or full.

*Taurus.*—The second sign of the ecliptic.

*Tide.*—The rising and falling of the waters of the ocean. The rising of the water is called flood tide; the falling, ebb tide.

*Transit.*—The passage of a body across the meridian of a place. The transit of Mercury and Venus usually means their apparent passage across the sun's disc.

*Trapezium.*—A figure bounded by four unequal sides.

*Triangle.*—A figure bounded by three lines, or sides. An equilateral triangle has three equal sides; an isosceles, only two; a scalene triangle has three unequal sides. A triangle is called a right, obtuse, or acute angled triangle, according as it has a right, obtuse, or three acute angles.

*Tropic of Cancer.*—A small circle, 23° 28′ north of the equator, and parallel to it.

*Tropic of Capricorn.*—A small circle, 23° 28′ south of the equator, and parallel to it.

*Tropical Year.*—The period between the consecutive returns of the sun to the same tropic or solstice.

*True Distance.*—The actual distance of a body from the sun, or of a satellite from its planet.

*True Place of a Planet.*—The place where it would appear to be, if seen from the centre of the earth, or centre of motion.

*Twilight.*—The faint light of the sun before sunrise and after sun-set.

*Umbra.*—A dark or total shadow.

*Universe.*—The whole material creation. It has been improperly applied sometimes to large clusters of stars.

*Vapor.*—Water in an æriform state—steam.

*Vertex.*—The head, top, or summit.

*Vertical.*—The direction of the plumb-line.

*Vertical Plane.*—A plane passing through the plumb-line, consequently perpendicular to the horizon.

*Vertical Circle.*—A circle in a vertical plane, passing through the zenith and nadir, and cutting the horizon at right angles.

*Virgo.*—The 6th sign of the ecliptic.

*Waning.*—Declining in power, or decreasing in light.

*West.*—That direction in which the sun sets when in the equinoxes.

*Wind.*—Air in motion. The trade winds blow steadily to the westward, in the Atlantic and Pacific oceans, between the tropics. The monsoons, or shifting trade winds, in the Indian ocean, blow part of the year one way, and the other part in an opposite direction. The winds beyond the 40th degree of latitude are all variable. In the torrid zone, near the sea, breezes blow from the land in the morning and from the sea in the evening.

*Year.*—A solar or tropical year is the period from the departure of the sun from the summer solstice, to its return to it again. Its length is 365 days, 5 hours, and nearly 49 minutes. The sidereal year, which is the period between the departure and return of the sun to a fixed star, is about 17 minutes longer. The anomalistical year is the time from the sun's leaving his apogee till he returns to it, and is 365 days, 6 hours, and about 14 minutes.

*Zenith.*—The point in the heavens directly over head.

*Zenith Distance.*—The angular distance of a heavenly body from the zenith, measured on a vertical circle.

*Zodiac.*—A space or belt in the heavens, 16 degrees broad, (8° on each side of the ecliptic,) in which are the orbits of all the planets except a part of the asteroids.

*Zone.*—A belt or girdle on the earth's surface, formed by circles parallel to the equator. There are five zones; the torrid, two temperate, and two frigid, formed by the tropics and polar circles.

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